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GROUND WATER

IN

SOUTH-CENTRAL PENNSYLVANIA

By
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of the U. S. Geological Survey

With Analyses by

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(Prepared in cooperation between the United States Geological Survey and
the Pennsylvania Topographic and Geologic Survey)

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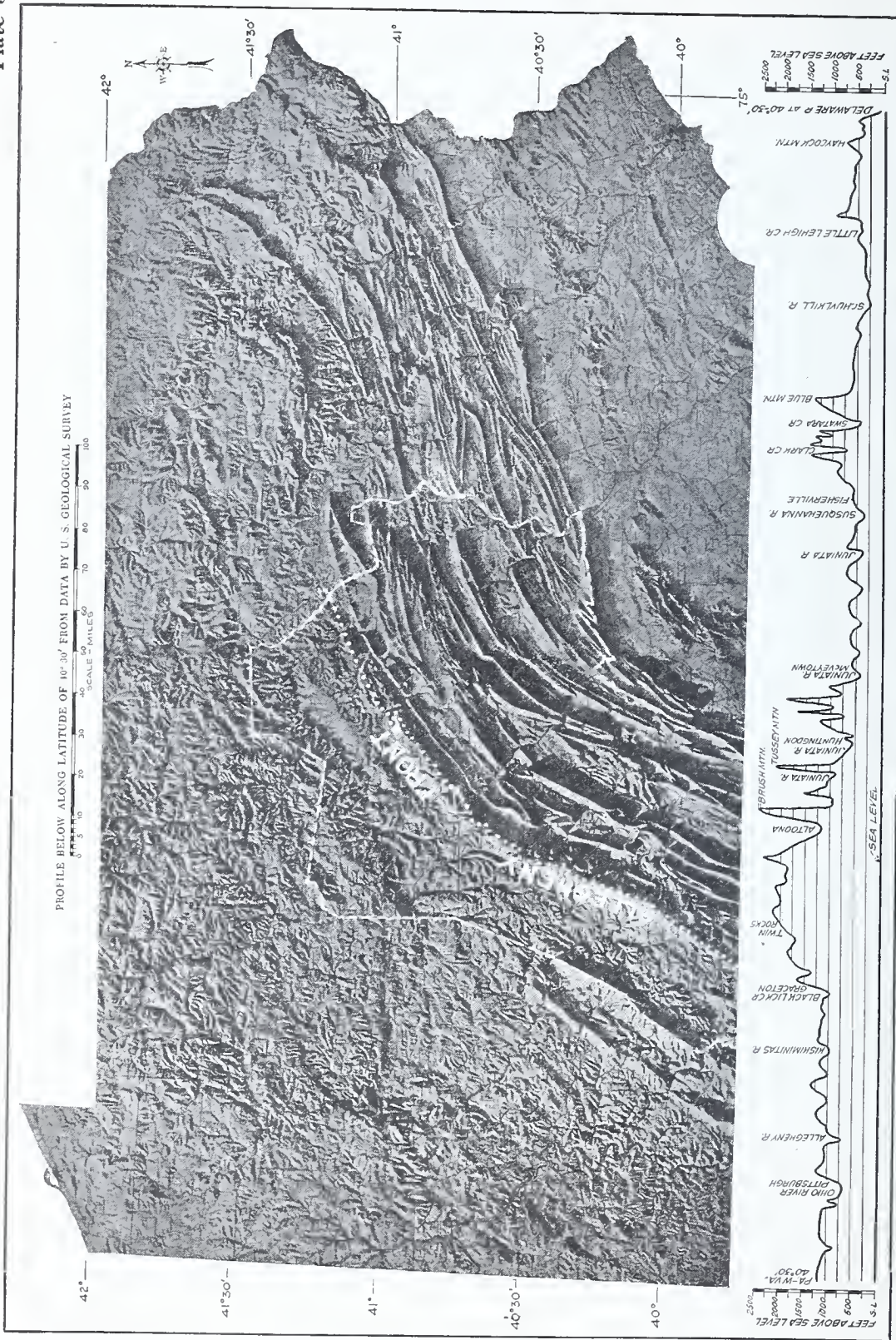
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Relief map of Pennsylvania and profile along latitude 40° 30'. Reproduced by permission from a reproduction of the original cast by Edward R. Harden

GROUND WATER IN SOUTH-CENTRAL PENNSYLVANIA

By STANLEY W. LOHMAN

ABSTRACT

This report describes the geography, geology, and ground-water conditions in an area comprising 9,769 square miles in the south-central part of Pennsylvania and including the 14 counties of Bedford, Blair, Cambria, Centre, Clearfield, Clinton, Fulton, Huntingdon, Juniata, Mifflin, Perry, Snyder, Somerset, and Union. It includes parts of two major physiographic provinces—the Ridge and Valley province and the Appalachian Plateaus province—which together include the most mountainous parts of the State. The highest point in the State is in Somerset County. The eastern Continental Divide traverses the area near the boundary between the two physiographic provinces. Part of the area is drained by tributaries of the Ohio River and the larger part by the Susquehanna and Potomac Rivers.

The population is largely rural, and there are only four cities having more than 10,000 inhabitants, the largest of which are Altoona, with 82,054 (in 1930), and Johnstown, with 66,993.

The area contains a classic section of the Paleozoic formations, and all the generally recognized Paleozoic systems—Cambrian, Ordovician, Silurian, Devonian, and Carboniferous—are well represented. There are, however, several pronounced disconformities. The structure is typical of the Appalachian region and includes many large folds and several overthrust faults. A few dikes of Triassic diabase are found in Perry County, and glacial and fluvial deposits of Pleistocene age and Recent fluvial deposits are present along some of the major streams, particularly at the northeast corner of the area.

In the rural sections dug wells and small springs supply most of the water for domestic and stock use, but drilled wells are also used extensively, and additional wells are being drilled each year to replace dug wells or to supply new homes and farms. Most of the geologic formations in the area yield sufficient water for domestic use, and many yield large quantities suitable for industrial and public supplies. The cities, many of the larger boroughs, most of the railroads, and a few of the larger industries are supplied with surface water from impounded streams, and there are innumerable undeveloped streams that could be thus utilized. More than 80 boroughs and villages obtain their water supplies, at least in part, from wells or springs, and numerous industries are supplied with ground water. Ground water is particularly favored by industries that require cold water of nearly constant temperature for cooling or condensing and by industries that require exceptionally clear water.

The Cambrian and Ordovician limestones and dolomites and the upper Silurian and Lower Devonian limestones and calcareous shales are probably the most productive water bearers in that part of the area lying in

the Ridge and Valley province. They supply numerous drilled wells, some of which yield as much as 500 gallons a minute, and supply many large springs. Those of Cambrian and Ordovician age in particular contain numerous caves, sink holes, and water-filled solution channels and give rise to the largest springs in the area, including Bellefonte Spring, in Centre County, which has a reported discharge of 31 second-feet, or about 14,000 gallons a minute and is believed to be the second largest spring in the State. Large supplies are also obtained locally from calcareous sandstones of the Oriskany group and from sand or gravel of Pleistocene and Recent age, although the latter deposits have not been exploited extensively. Most of the ground waters in the Ridge and Valley province are of suitable quality for most ordinary purposes and range from soft to moderately hard. Some of the waters from limestones and calcareous shales of the Cayuga group and the Helderberg limestone, however, are excessively hard and are unsuited for many purposes, such as boiler feed. Relatively few waters in the Ridge and Valley province contain dissolved iron in large amounts, and very few contain much sodium chloride.

In that part of the area lying in the Appalachian Plateaus province abundant supplies of ground water are obtainable in many places from sandstones of the several Carboniferous formations, of which those of the Pottsville formation are especially productive. However, some of the waters—particularly some of the Pottsville waters—have a high content of dissolved iron, which is an especially disagreeable constituent of many ground waters in a large part of western Pennsylvania. Where present, however, it can be removed by simple treatment. In this part of the area drilled wells are utilized extensively to furnish industrial and public supplies. Considerable coal is mined in this region, and in some places wells and springs have been dried up by the lowering of the water table resulting from mine drainage. In some of the deeper synclinal basins deep wells are likely to encounter brackish or salty water.

The basic field data upon which most of this report is based are contained in the 14 separate county descriptions and comprise tabulated records of more than 1,100 wells and springs, chemical analyses of 92 samples of ground water from representative wells and springs and of 5 samples of water from streams. Descriptions are given of all public supplies that utilize ground water as a sole or auxiliary source. In addition, the weekly depths to water level in 4 unused wells since the fall of 1931 are given in graphic form.

INTRODUCTION

PURPOSE AND SCOPE OF THE INVESTIGATION

The investigation upon which this report is based is the fifth unit of a program undertaken by the Pennsylvania Topographic and Geologic Survey in cooperation with the United States Geological Survey to determine the underground-water conditions in the entire State. The purpose of this survey is to inventory the principal sources of ground water throughout the State, so that an individual, industry, or municipality may find the information necessary for a satisfactory and economical solution of its water supply problems so far as they concern water from subterranean sources.

The field work for this report was carried on for 21½ months during the summer and fall of 1933 and 21½ months during the summer of 1934. Records were collected of 1,173 wells and springs that furnish municipal, industrial, and domestic supplies, and well owners and drillers were interviewed. Only those village, borough, and city water supplies were investigated that utilize ground water, no study being made of those using water from streams or lakes. Some time was devoted to a study of the rock formations.

In order to determine the chemical character of water in different parts of the area, samples of water were collected from 92 representative wells and springs and, for the purpose of comparison, 5 samples were collected from surface streams. These samples were analyzed in the water-resources laboratory of the United States Geological Survey, mainly by E. W. Lohr but in part by Margaret D. Foster and W. L. Lamar.

The physical properties of two samples of sandstone were determined by V. C. Fishel in the hydrologic laboratory of the United States Geological Survey.

The work was carried on under the supervision of O. E. Meinzer, geologist in charge of the division of ground water, United States Geological Survey, and G. H. Ashley, State geologist of Pennsylvania. The manuscript of this report received the constructive criticism of G. W. Stose and G. B. Richardson, of the geologic branch of the United States Geological Survey.

LOCATION AND EXTENT OF THE AREA

The area described in this report embraces 9,769 square miles in the south-central part of Pennsylvania, and includes the 14 counties of Bedford, Blair, Cambria, Centre, Clearfield, Clinton,

Fulton, Huntingdon, Juniata, Mifflin, Perry, Snyder, Somerset, and Union. The area lies between meridians $76^{\circ} 45'$ and $79^{\circ} 30'$ west longitude and parallels $39^{\circ} 40'$ and $41^{\circ} 30'$ north latitude. The location of the area with respect to the boundaries of the State and to the other units of the State-wide ground-water survey is shown by figure 1.

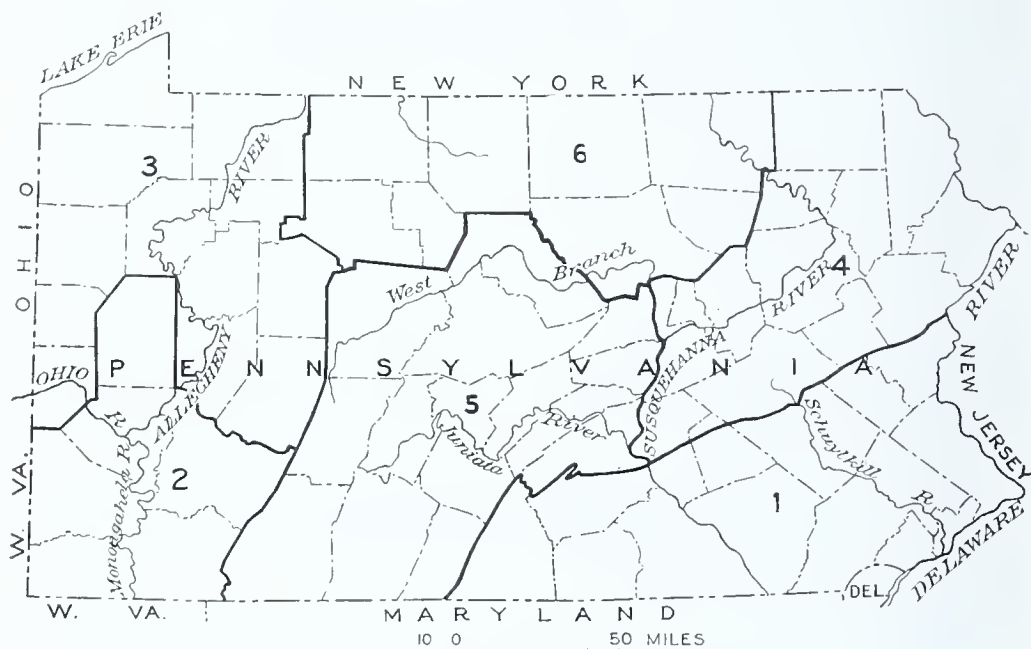


Figure 1. Index map of Pennsylvania, showing areas covered by this series of ground-water reports. 1, Southeastern Pennsylvania, Bull. W2; 2, South-western Pennsylvania, Bull. W1; 3, Northwestern Pennsylvania, Bull. W3; 4, Northeastern Pennsylvania, Bull. W4; 5, South-central Pennsylvania, this report; 6, North-central Pennsylvania, report in preparation.

This area is called South-central Pennsylvania on the title page and in some places in the text. Also in the text it is called central and south-central Pennsylvania. This inconsistency is the editor's. Figure 1 shows the area covered by this report which will be followed by another covering the remaining north-central counties.

PREVIOUS INVESTIGATIONS

In the following bibliography no attempt has been made to include all the reports that touch upon the geology of the area, but merely to list those geologic reports, most of which contain areal geologic maps, from which most of the descriptions of geologic formations or structure were taken and which furnished the basis for determining the geologic horizons of the water-bearing beds encountered in wells. The list also includes a few reports dealing with ground-water conditions in the area. Some of these reports and others not listed here are acknowledged by footnotes throughout the present report.

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UNPUBLISHED REPORTS

The following unpublished reports and maps were used in the preparation of the present report, through the courtesy of the several authors:

Ashley, G. H., Description of the geology and mineral resources of the Curwensville quadrangle (typewritten), with geologic maps of the Curwensville and Houtzdale quadrangles.

Bonine, C. A., Geologic map of the Bedford quadrangle.

Butts, Charles, U. S. Geol. Survey Geol. Atlas, Hollidaysburg-Huntingdon folio (no. 227) (galley proof).

Butts, Charles, Description of the Tyrone quadrangle (typewritten).

Sisler, J. D., Geologic map of the Meyersdale quadrangle.

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This report would not have been possible without the cooperation of well drillers and well owners throughout the area.

The writer is particularly indebted to the following persons, who kindly put at his disposal their then unpublished geologic maps and reports of the areas indicated: G. H. Ashley, State geologist of Pennsylvania, for the Curwensville and Houtzdale quadrangles; J. D. Sisler, former State geologist of West Virginia, for the Meyersdale quadrangle; Bradford Willard, geologist, Pennsylvania Geological Survey, for reports on several Devonian formations in central Pennsylvania; C. A. Bonine, head of the department of geology, Pennsylvania State College, for the Bedford quadrangle; Charles Butts, geologist, United States Geological Survey, for the Bellefonte, Tyrone, Huntingdon, and Hollidaysburg quadrangles and parts of the Altoona, Allensville, and Philipsburg quadrangles; and G. B. Richardson, geologist, United States Geological Survey, for the Somerset and Windber quadrangles.

The writer expresses his thanks to the following residents of the State, who contributed valuable information regarding ground-water conditions in different parts of the area: Bert Rowles, assistant supervisor of bridges and buildings, New York Central Railroad, Clearfield; H. M. Van Zandt, engineer in charge, Bituminous Mine Drainage Survey, Greensburg; M. J. Barrick and R. C. Gorman, district engineers, Pennsylvania Department of Health, Williamsport and Harrisburg, respectively; W. R. Dougan, Somerset; L. M. Carter, engineer, Consolidation Coal Co., Somerset; R. Phaler, chief engineer, Berwind-White Coal Co., Windber; D. Fleming, engineer, Ebensburg Coal Co., Colver; Mr. Shobert, Buffalo & Susquehanna Coal Co., Sykesville; Mr. Nagel, engineer, Northwest Mining & Exchange Co., Du Bois; Mr. Milliron, city engineer, Du Bois; R. Heil, engineer, West Virginia Pulp & Paper Co., Tyrone; S. Bloom, Curwensville; and Ralph R. Cleland, sanitary engineer, Department of Grounds and Buildings, Pennsylvania State College, State College.

GEOGRAPHY

PHYSICAL DIVISIONS

The physical divisions represented in Pennsylvania are shown in figure 2. Differences in topography, rocks, and geologic structure form the basis for a natural subdivision of the Appalachian Highlands into several provinces.¹ The area described in this report lies within two of these provinces, the Ridge and Valley province and the Appalachian Plateaus province. The boundary

¹Fenneman, N. M., *Physiographic divisions of the United States*, 3d ed.: Assoc. Am. Geographers Annals, vol. 18, no. 4, 1928.

between these two provinces, known as the Allegheny Front, is perhaps the most striking topographic feature of the area and is shown in plates 3 and 4, A.

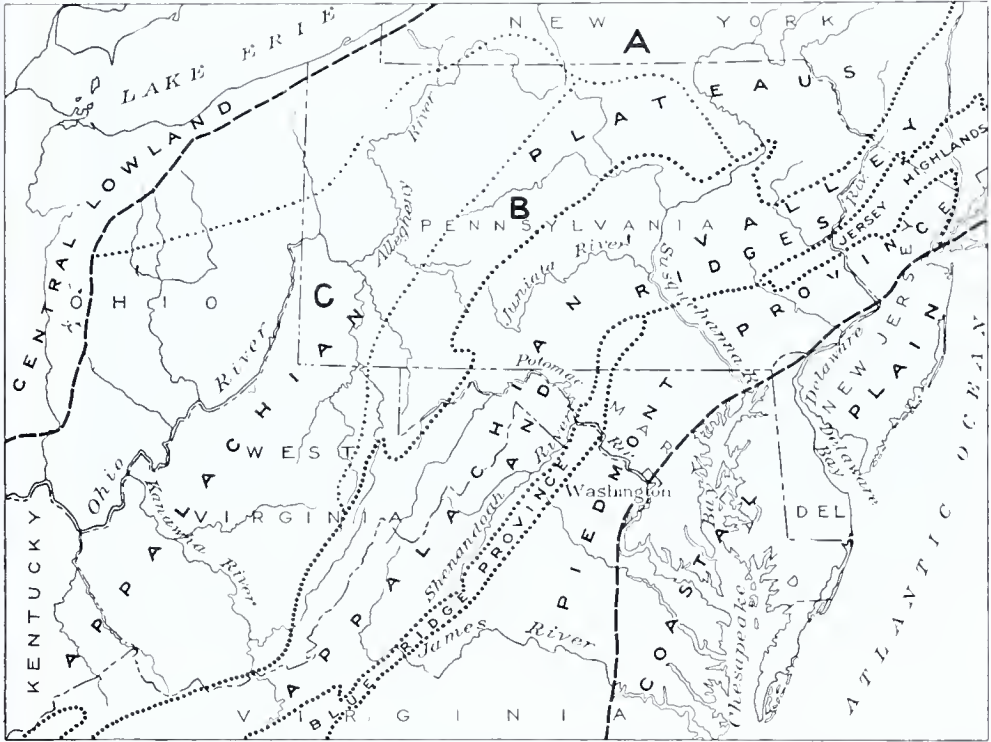


Figure 2. Map of Pennsylvania and adjoining States showing the major physical divisions. Subdivisions of the Appalachian Plateaus province: A, Allegheny Mountain section; B, Southern New York section; C, Kanawha section.

Ridge and Valley province.—The Ridge and Valley province, which includes most of the area, comprises an alternate succession of narrow ridges and broad or narrow valleys trending generally northeast and curving toward the east in the northern part of the area. This is a region of alternating hard and soft sedimentary rocks that have been severely folded by lateral compression from the southeast into a series of anticlines and synclines. After the rocks had been folded the whole area was slowly base-leveled by erosion, and hard and soft layers alike were reduced to a nearly uniform surface. Then followed a general uplift of the region that gave the streams renewed vigor and began another period of erosion, which has continued to the present time. As a result of this erosion the softer rocks have been eroded forming valleys, and the more resistant rocks stand out as long, narrow, even-crested ridges, as shown in plates 3 and 4, A.

The southern border of the area in Perry County, a conspicuous ridge called Kittatinny or Blue Mountain, is also the boundary between the Ridge and Valley province and the Cumberland Valley.

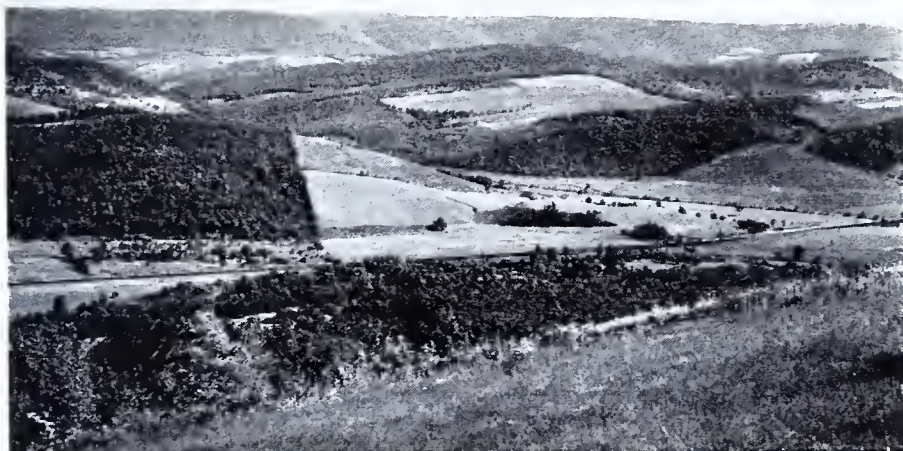
Appalachian Plateaus province.— All of the area that lies west of the Allegheny Front is in the Allegheny Mountain section of the Appalachian Plateaus province, except a small part of Clearfield County, which lies in the adjoining Kanawha section. The Allegheny Mountain section is a high, mature plateau surmounted in its eastern portion by several high ridges. The Kanawha section stands at a lower altitude, and its plateaus have somewhat less relief than the Allegheny Mountains.

In striking contrast with those of the Ridge and Valley province, the strata of the Appalachian Plateaus province have been disturbed but slightly from their original attitude and lie nearly horizontal in most places. The physiographic evidence supports the conclusion that the rocks of the plateaus have been base-leveled in common with those of the Ridge and Valley province, and, after subsequent uplift, the streams have dissected the surface of the old peneplain so that it now presents the appearance of a hilly country. However, evidences of the former plain are seen in the remaining hilltops, as shown in plate 5.

TOPOGRAPHY

Relief.— The area includes the highest and most mountainous parts of the State. The highest point in the area, as well as in the State, is in the Allegheny Mountain section, where Mount Davis, on Negro Mountain in Somerset County, stands at an altitude of 3,213 feet. It is of interest that a well was drilled successfully on the summit of Mount Davis (well 913, p. 292). The lowest point in the area is in the Susquehanna Water Gap, in Perry County, and has an altitude of only about 310 feet. The area as a whole, therefore, has a maximum relief of about 2,900 feet.

The greatest local relief is along the Allegheny Front, where the crests stand 1,300 to 1,800 feet above the adjacent valleys, and in the Ridge and Valley province, where numerous ridges stand 600 to 1,800 feet above the adjacent valleys. A relief of 1,600 feet is found in the Appalachian Plateaus province along each of three deeply incised rivers, the Casselman, the Cone-maugh, and the West Branch of the Susquehanna. A considerable part of the area in this province stands at an altitude of more than 2,000 feet, numerous ridges stand above 2,500 feet, and small areas stand above 3,000 feet. Many of the ridges in



A. Allegheny Front, looking northwest across Bald Eagle Valley from Buffalo Run Gap on Bald Eagle Mountain, Centre County.



B. Typical Ridge and Valley topography. Looking west across Sheaffer Valley toward Bowers Mountain from a point a quarter of a mile north of Doubling Gap, Perry County.



A. Appalachian Plateaus, Allegheny Mountain section, looking east from a point 1 mile west of Faunce, Clearfield County.



B. Dissection of Appalachian Plateaus, Allegheny Mountain section, looking west from a point in northern Johnstown, Cambria County. Laurel Ridge in background, with Conemaugh River gap at right; byproduct coking plant at Rosedale in foreground.

the western part of the Ridge and Valley province are more than 2,000 feet above sea level, and a few reach 2,400 to 2,700 feet. In the distance of 125 miles between Harrisburg and the Allegheny Mountains of Somerset County the altitudes of the highest ridges increase gradually from about 1,200 feet to more than 3,000 feet. The relief within the larger valleys of the Ridge and Valley province ranges from 100 to more than 500 feet but is generally 200 to 300 feet. The relief in each county is given in the county descriptions.

Drainage.—The eastern Continental Divide traverses the area west of the Allegheny Front. The drainage therefore flows chiefly to the Atlantic Ocean, but a small part flows to the Gulf of Mexico.

Almost all the area east of the divide is drained by the Susquehanna River, which forms the eastern boundary of the area, but parts of Bedford and Fulton Counties are drained by tributaries of the Potomac River. The Susquehanna drainage is carried by the Juniata River, the West Branch of the Susquehanna River, and small streams directly tributary to the main Susquehanna River. The area includes the entire drainage basin of the Juniata River.

Nearly all of Somerset County, about two-thirds of Cambria County, and a small area of northwestern Clearfield County are drained by tributaries of the Ohio River, chiefly by the Conemaugh River and other tributaries of the Allegheny River but in part by the Youghiogeny River.

POPULATION

According to the census of 1930 the 14 counties covered by this report had a population of 787,359, and an average density of population of 80.6 inhabitants to the square mile, as compared with 214.8 for the entire State. There are only four cities in the area having more than 10,000 inhabitants, and only two having more than 50,000—Altoona, with 82,054 (in 1930), and Johnstown, with 66,993. Cambria County has the greatest density of population, with 283.3 inhabitants to the square mile, and Fulton County has the smallest, with only 22.9 inhabitants to the square mile. The population of the counties and larger towns is given in the county descriptions.

TRANSPORTATION

The area as a whole is well served by railroads, except for Fulton County, in which the only railroad is a spur of the East Broad Top Railroad, which projects about a quarter of a mile

into the county. The area is crossed by the main line of the Pennsylvania Railroad and is well covered by its many branch lines including the Erie division, which traverses Clinton County. The New York Central Railroad has a line in Centre, Clearfield, and Clinton Counties, and the Buffalo, Rochester & Pittsburgh Railroad (Baltimore & Ohio system) crosses Clearfield County. Southern Somerset and Bedford Counties are served by the Baltimore & Ohio Railroad and the Western Maryland Railroad. The Reading Railway serves parts of Union and Snyder Counties. In addition to these large systems, there are several small railroads—the Huntingdon & Broad Top Mountain, East Broad Top, Bellefonte Central, and Central of Pennsylvania. Several narrow-gage railroads have been abandoned in recent years, including the Tuscarora Valley and the Shermans Valley, in Juniata and Perry Counties.

The area is covered by a network of modern highways, and in recent years many of the country roads have been macadamized. The most traveled highways crossing the area are the William Penn Highway, which follows the Juniata River; the Susquehanna Trail, which follows the Susquehanna River; the Buck Tail Trail, which follows the West Branch of the Susquehanna River; and the Lincoln Highway, which traverses the mountains through Somerset, Bedford and Fulton Counties.

In years past canals were used along the principal rivers, but these have all been abandoned in favor of better methods of transportation.

AGRICULTURE

Nearly 49 percent of the total land area in the 14 counties was devoted to farming in 1930. Snyder and Fulton Counties ranked first and second, with 70.1 percent and 65.3 percent of their total land area under cultivation, and Clinton County ranked last, with only 16.7 percent of its total land area under cultivation.

The main crops grown on the plateaus are corn, oats, wheat, rye, and grass, but buckwheat and potatoes are also grown extensively. The plateaus have fair soil, but although many of the farms yield excellent returns, most of them are not in a prosperous condition and yield their owners only a bare living. Many untenanted farms are found in this part of the area, some of which are owned by coal companies that are interested only in the mineral rights.

The general crops grown in the Ridge and Valley province are the same as on the plateaus, except that rye is not cultivated as extensively. A high state of agricultural development is found

in the numerous broad limestone valleys that form so conspicuous a feature of this province, but in the narrower valleys of shale and sandstone many of the farms are not in a prosperous condition. Considerable milk is shipped from the eastern part of the area to Philadelphia and other cities.

NATURAL RESOURCES AND INDUSTRIES

South-central Pennsylvania is well endowed with natural resources which have opened the way for numerous industries.

Coal is by far the most valuable resource of the plateau counties. Low-volatile semibituminous coal is mined extensively in Cambria, Clearfield, and Somerset Counties, and to a lesser extent in Blair, Centre, and Clinton Counties. Semibituminous coal is mined in the isolated Broad Top coal field, in Bedford, Fulton and Huntingdon Counties. The ready availability of coal over much of the area has given rise to important industries, such as the steel furnaces and byproduct coke plants at Johnstown. (See plate 5, B.)

Some natural gas has been obtained in Cambria, Centre, Clearfield, Clinton, and Somerset Counties, but oil in commercial quantities has not been found in this area.

Pennsylvania is the leading producer of silica brick, most of which is made in this area from ganister, a rock derived from the Tuscarora quartzite, the principal mountain-making formation in the Ridge and Valley province. Silica brick is made from ganister in Bedford, Blair, Centre, Clinton, Huntingdon, Juniata, and Mifflin Counties.

Pennsylvania is the leading State in the production of glass sand, and central Pennsylvania is by far the chief producer, both as regards the total tonnage of glass sand produced and as regards the better quality of the sand for glass making. The sand comes from the Oriskany group and is quarried extensively at several localities in Huntingdon and Mifflin Counties. The Oriskany is also quarried for building sand in Bedford, Blair, and Centre Counties and for molding sand in Mifflin County. (See plate 6, A.)

Building stone for local use is available in all the counties in the area, and considerable sandstone has been quarried and shipped from the Homewood sandstone member of the Pottsville in Clearfield County.

Clearfield County is probably the leading producer of flint clay in the State. Flint clay is also produced in Cambria, Centre, and Clinton Counties.

The mining of hematite iron ore from the Clinton formation and limonite iron ore from Cambrian and Ordovician limestone was a thriving industry along the Juniata River many years ago, but none of this iron ore is workable commercially at present.

Limestone quarries have been opened and operated in the area wherever limestone occurs, the rock being used for flux, burning, building, road material, railroad ballast and in some places for high-grade chemical lime. The principal quarries are near Bellefonte, Tyrone, Hollidaysburg, Birmingham, and Lewistown. (See pl. 6, B.)

In the early history of the area lumbering and tanning were very important industries, but at the present time practically all the timber land has been cut over—much of it having been cut twice or more—and the lumbering industry has nearly disappeared. In 1934 only five tanneries were observed in operation, three in Clearfield County and two in Clinton County. Some timber is used for making paper and pulp, and there are large paper mills at Lock Haven, Tyrone, Williamsburg, and Roaring Spring.

Hydroelectric power has been developed on the Juniata River near Petersburg, and on small streams near Milesburg and Roaring Spring. There are numerous undeveloped power-sites along the major streams. Electric power is also developed from steam at several places—notably along the Raystown Branch of the Juniata River at Saxton.

Another important natural resource of the area is ground water, the occurrence and uses of which are described in this report.

CLIMATE

In general the heaviest precipitation in the area occurs in the highest parts of the Allegheny Mountains. The annual precipitation in the area averages about 40 inches, ranging from 35.5 inches at Altoona, which is in the lee of the Allegheny Front, to 50.8 inches at Somerset, which is on the high plateau. The greatest annual precipitation on record was 66.6 inches at Somerset in 1890. The dryest year on record was 1930, when only 27.3 inches fell at Somerset and 23.9 inches at Altoona. In 1930 the precipitation at all the stations ranged from 10 to 24 inches below normal. In 1895 the precipitation at Altoona was only about 21 inches, but the dryness was only local, and there was no widespread drought such as existed in 1930.

Although the precipitation is fairly well distributed throughout the 12 months of the year, the heaviest rainfall occurs in May, June, July, and August, with the maximum in June and relatively low rainfall occurs in October, November, and February. Thus the heaviest precipitation occurs during the growing season, when it is of the most benefit to crops.

The average annual snowfall ranges from about 36 to 52 inches in the Ridge and Valley province and reaches about 88 inches on the high plateau at Somerset. Most of the snow falls between November and April, but on the high plateau some snow generally falls during October, and in some years traces of snow have been recorded in May in both provinces.

The mean annual temperature ranges from 46.8°F. at Ebensburg to 51.5°F. at Hyndman. January, with average temperatures of 23°—30°F., is the coldest month, and July, with average temperatures of 67°—73°F., is the warmest. Temperatures as high as 106°F. have been recorded at several places, and temperatures as low as minus 34°F. have been recorded at Clearfield. The first killing frost in the fall generally occurs late in September or early in October, and the last killing frost in the spring generally occurs sometime in May. The average length of the growing season ranges from 120 to 160 days.

The chief climatic data for eleven stations in the area are summarized in the following table:

Summary of climatic data for eleven stations in south-central Pennsylvania

[From U. S. Weather Bureau]

	Altitude above sea level (feet)	Precipitation		Temperature		Average length of growing season (days)	Snowfall	
		Length of record (years)	Mean annual (inches)	Length of record (years)	Mean annual (°F.)		Length of record (years)	Mean annual (inches)
Ridge and Valley province								
Lock Haven.....	580	44	41.00	44	50.9	161	39	52.1
State College.....	1,217	50	38.88	46	48.6	157	41	45.9
Selinsgrove.....	455	45	42.32	45	50.8	157	39	41.7
Altoona.....	1,615	47	35.51	38	49.2	152	.....	.....
Huntingdon.....	650	47	40.65	47	50.7	153	41	37.9
Mifflintown.....	445	27	40.20	28	50.6	153	34	36.7
Hyndman.....	977	22	37.68	22	51.5	148	18	37.2
Appalachian Plateaus province								
Clearfield.....	1,120	27	43.86	24	49.4	146	.....	.....
Ebensburg.....	2,000	17	41.73	17	46.8	121	13	44.2
Johnstown.....	1,184	53	47.51	45	51.4	163	40	52.5
Somerset.....	2,190	52	50.81	67	47.6	135	40	87.9

GEOLOGY

SUMMARY OF STRATIGRAPHY

The consolidated rocks that crop out in the area are all of Paleozoic age except a few dikes of Triassic diabase in Perry County. All the Paleozoic systems — Cambrian, Ordovician, Silurian, Devonian, and Carboniferous—are well represented. Pleistocene glacial deposits are found along some of the streams in the north-eastern part of the area.

The older systems are exposed only in the Ridge and Valley province. The rocks exposed in the Appalachian Plateaus province are all of Carboniferous age except for a few exposures of Devonian rocks in the northern part and two small spots in southwest Somerset County. The oldest formation known to be exposed in the area is the Waynesboro formation, of Lower Cambrian age, and the youngest undoubted Paleozoic formation is the Monongahela formation—the youngest formation of the Pennsylvanian series. Gardner,² following the view of the Second Geological Survey of Pennsylvania, thought that the Monongahela formation and a portion of the Dunkard group were present in the Broad Top coal field of Huntingdon, Bedford, and Fulton Counties, but admitted that in the absence of paleontologic evidence their identification was not positive. Sisler,³ however, doubts the presence of beds younger than the Conemaugh in the Broad Top coal fields.

Since the reconnaissance work of the Second Geological survey of Pennsylvania the geology of somewhat less than half of the area has been resurveyed in the central and western parts and several geologic folios describing small parts of the area have been published by the United States Geological Survey and the Pennsylvania Topographic and Geologic Survey. The areal distribution of the formations mapped by the Second Geological survey and those that have been remapped are shown on plate 1. In the present report the stratigraphic nomenclature of the later reports has been followed wherever possible. Regional descriptions of the formations and the occurrence of ground water in them are given on pages 82-122. The rocks are described in ascending order—the order in which they were deposited. A generalized section of the geologic formations of central and south-central Pennsylvania follows:

² Gardner, J. H., The Broad-Top coal field of Huntingdon, Bedford, and Fulton Counties: Pennsylvania Topog. and Geol. Survey Comm. Rept. 10, p. 28, 1913.

³ Sisler, J. D., Bituminous coal fields of Pennsylvania; Detailed descriptions of coal fields: Pennsylvania Topog. and Geol. Survey, 4th ser., Bull. M 6, pt. 2, p. 282, 1926.

General section of the geologic formations of south-central Pennsylvania

Era	System	Series	Subdivision	Thickness (feet)	Physical character	Ground-water conditions
Cenozoic	Quaternary	Recent	Alluvium. —Unconformable on older formations—	0-60±	Sand, gravel, and silt.	Yields small supplies of water to dug or driven wells in the larger stream valleys.
		Pleistocene	Jerseyan, Illinoian, and Wisconsin drift and fluvial deposits. —Unconformable on older formations—	0-135+	Sand, gravel, silt, and clay.	Important potential source of ground water in Clinton County, where large supplies could probably be obtained in some places.
	Tertiary (?)		Terrace deposits. —Unconformable on older formations—	—	Scattered stream gravel found 400 feet above present stream level, considered of late Tertiary (?) age.	Unimportant.
	Triassic		Diabase. —Intrusive relations— Monongahela formation.	—	Four dikes of hard, very tough diabase cutting Paleozoic sediments in southeastern Perry County.	Unimportant; no wells; poor water-bearer and difficult to drill.
Mesozoic				70-100+	Shale, sandstone, limestone, and coal. Contains at the base the important Pittsburgh coal.	Unimportant; no wells observed.
Paleozoic	Carboniferous	Pennsylvanian	Conemaugh formation.	570 (?) -960±	Variable sequence of sandstone, shale, clay, thin coals (locally workable), and thin beds of limestone. Characterized by thin but persistent limestones and a few beds of red shale.	A productive water-bearer in Cambria and Somerset Counties; unimportant elsewhere. Several sandstone members yield as much as 250 gallons a minute. Some waters contain excessive amounts of iron, but waters generally better than those of Allegheny or Pottsville.
			Allegheny formation	220-350	Variable sequence of sandstone, shale, clay, limestone, fire clay, and coal. Coals and fire clay are of considerable economic importance and are mined extensively.	A good water-bearer in places distant from coal mines. Shales yield small supplies; sandstones yield 50 to 150 gallons a minute. A few flowing wells. Some waters contain excessive amounts of iron, but waters generally softer and better than those of Pottsville.
			Pottsville formation.	130-375	Largely hard sandstone (locally shaly and conglomeratic), important mountain-maker. Contains, from top to bottom, Homewood sandstone member, Merceer shale member, Connoquenessing sandstone member, and locally Sharon member.	Probably the most productive water-bearer in the Appalachian Plateaus province (except Clinton County); many artesian wells and some flowing wells. Yields 100 to more than 400 gallons a minute to many wells. Water generally poor, owing to large content of iron. Unimportant in Ridge and Valley province

[illegible]

General section of the geologic formations of south-central Pennsylvania

Era	System	Series	Subdivision	Thickness (feet)	Physical character	Ground-water conditions
Paleozoic	Devonian	Lower Devonian	Oriskany group	20 ± - 200 ±	Highly fossiliferous fine- to coarse-grained white to brown calcareous to pure sandstone, locally conglomeratic. Weathers to loose sand.	Productive water-bearer where thick and below drainage level. Supplies many domestic wells and yields large supplies to a few industrial wells. Several large springs. Water of good quality, generally soft and iron-free.
			Slight disconformity (?)			
			Sbriver chert.	0 (?) - 300	Variable; ranges from thin-bedded, highly siliceous limestone or calcareous sandstone to gray or black shale. Generally contains more or less chert.	Supplies a few domestic wells, but relatively unimportant. No samples of water obtained.
			Slight disconformity			
			Helderberg limestone.	150 - 350 ±	New Scotland limestone member at top, shale and impure limestone; Coeymans limestone member, ranges from limestone, in part sandy, to calcareous sandstone; Keyser limestone member at base, limestone, shaly near top.	
		Silurian	Slight disconformity (?)	?	Thin-bedded to laminated fine-grained dark-blue to black limestone. Locally contains calcareous shale.	Helderberg and Tonoloway limestones yield large supplies to wells that encounter solution channels. Wills Creek, Bloomsburg, and McKenzie yield small supplies to wells ending only in shale, but moderately large supplies to wells encountering limestone. Only two samples contain excess iron, but most of the waters are very hard, and some are highly concentrated calcium sulphate waters. In general the waters of the Cayuga group are the poorest in the entire area.
			Tonoloway limestone.	800 ±		
			Wills Creek shale (restricted).	400 ± - 750 ±	Chiefly thin fissile calcareous gray shale with thin layers of limestone. Locally contains red shale. Contains gypsum in some localities.	
			Bloomsburg redbeds.	50 - 500 +	Generally largely nonfissile lumpy red shale with smaller amounts of gray, green, or yellow shale, red sandstone, and locally impure limestone; but along the Maryland boundary it is entirely red sandstone.	
			McKenzie formation.	110 - 400 ±	Generally chiefly greenish and some red shale interbedded with many thin layers of limestone, but locally limestone predominates.	
		Clinton formation.	Disconformity (?)		Largely gray and greenish shale with a small proportion of limestone and greenish and red sandstone. Contains beds of fossiliferous or oolitic iron ore. Keefer sandstone member near top.	Sandstones abundantly water-bearing; shales will not yield much more than 50 gallons a minute even to deep wells. Water generally very soft and low in dissolved solids. One deep well yields saline water.
				640 ± 940 +		
	Tuscarora quartzite			270 - 850 ±	White to gray medium thick-bedded, quartz sandstone or quartzite, ranging in texture from hard fine-grained, firmly cemented quartzite to loosely cemented conglomeratic sandstone.	Unimportant owing to topographic position. Supplies hillside springs. Only one shallow domestic well observed in it. Water probably soft.

Paleozoic		Ordovician							
Upper Ordovician	Juniata formation.	—Local disconformity—		Martinsburg shale as originally defined and used in Fulton County, 2,000 feet	Martinsburg shale redefined.	68-1,200±	Consists almost wholly of unfossiliferous red or brown sandstone and shale.		Unimportant owing to topographic position. Yields small supplies of good water to a few shallow domestic wells and hillside springs. Has not been exploited for large supplies.
	Oswego sandstone.	—					Brown to gray thick-bedded fine- to coarse-grained sandstone; locally contains conglomerate and red, gray, or green shale. Some beds arkosic, some beds cross-bedded.			Unimportant owing to topographic position. Yields small supplies of very soft water to wells and springs, but large supplies apparently not obtainable.
	Reedsville shale.	—		Chambersburg limestone as originally defined and used in Fulton County, 100± feet	Chambersburg limestone (Chambersburg limestone restricted to Lowville limestone in Fulton County) 160 feet	100±-1,200±	Chiefly brown, greenish, and black clayey to sandy shale, generally black in lower part, with thin limestone beds or concretions, some pyrite, carbonaceous shale, grading upward into sandstone. Upper 1,200 feet of Martinsburg is sandstone.		Yields small but reliable supplies to shallow wells, and not much more to deeper wells: 40 to 50 gallons a minute probably maximum yield of obtainable, with large draw-down. Water moderately hard; one sample contains excess iron, but water generally satisfactory.
	Trenton limestone.	—Disconformity—					Rodman limestone.			350-630	Thin-bedded dark compact or noncrystalline, moderately argillaceous and siliceous limestone.
Middle Ordovician	Black River group	—Local disconformity—		Lowville limestone.		20-30	Persistent thin-bedded impure, very fossiliferous limestone.		
		—		Dark compact pure limestone with tendency to conchoidal fracture.					
Lower Ordovician	Carlisle limestone (of Chazy age).	Disconformity—		Stones River limestone in Fulton County 160 feet		100-400±	Mainly pure dark-bluish, finely crystalline limestone; some dolomites near base, Lenont argillaceous limestone member at top of Carlisle. Stones River also largely pure limestone.		Abundantly water-bearing to wells that encounter water-filled solution channels. Wells that do not encounter these openings may yield little or no water, but very few dry holes have been reported. Unpromising wells should not be drilled below a depth of 350 to 400 feet below the local water table or local drainage level. Many large tubular springs. Ground waters are only moderately concentrated and moderately hard, and are much softer and less concentrated than those from the Silurian and Devonian limestones.
		Disconformity—		Bellefonte dolomite.			Principally dark fine-grained thin-to thick-bedded dolomite, with a few light gray beds, a little dove-colored limestone, a little chert, and locally in Centre County it contains a sandstone bed near the middle.		
	—Local disconformity—		Avennum limestone.		0-500±	Comparatively pure thin-bedded dark bluish-gray limestone, with only a few thin layers of dolomite.			
	—Local disconformity—		Nittany dolomite.			Chiefly light-gray or bluish-gray fine-grained dolomite, with an abundance of chert in lower part, some of which is oolitic.			

General section of the geologic formations of south-central Pennsylvania

Era	System	Series	Subdivision	Thickness (feet)	Physical character	Ground-water conditions
Paleozoic	Ordovician	Lower Ordovician	Beekmantown Group		Chiefly relatively pure blue limestone, with some magnesian limestone and dolomite. Locally it contains edgewise conglomerate, oolitic limestone, calcareous shale, and a basal limestone conglomerate.	Abundantly water-bearing to wells that encounter water-filled solution channels. Wells that do not encounter these openings may yield little or no water, but very few dry holes have been reported. Unpromising wells should not be drilled below a depth of 350 to 400 feet below the local water table or local drainage level. Many large tubular springs. Ground waters are only moderately concentrated and moderately hard, and are much softer and less concentrated than those from the Silurian and Devonian limestones.
			Stonehenge limestone.	0-702		
			-Local disconformity— Larks dolomite.	0-250±	Chiefly thick-bedded, coarsely crystalline dark-blue dolomite; very little sandstone or chert.	
			Mines dolomite.	150-250±	Chiefly dolomite with an abundance of chert, much of which is oolitic.	
	Cambrian	Upper Cambrian	Gatesburg formation.	1,600-1,750	Chiefly dolomite with many intercalated layers of sandstone or quartzite, and a few beds of silicified oolite. Locally it contains the Stacy dolomite member at the base (500 feet thick) and the Ore Hill limestone member near the middle (100 feet thick).	Unimportant; small areal extent. No data obtained but will probably yield some water.
			—Disconformity— Warrior limestone.	1,250	Chiefly limestone and dolomite with some beds of siliceous shale or shaly sandstone, quartzite, oolite, and in places edgewise conglomerate.	
		Middle Cambrian	Pleasant Hill limestone.	500	Lower part is argillaceous sandy micaceous limestone with some calcareous shale; upper part thick-bedded dark-gray limestone.	
		Lower Cambrian	Waynesboro formation.	300±	Green, purple, and dark shale, thin-bedded fine-grained greenish sandstone, quartzite, and quartz conglomerate.	

^a Equivalent to upper Chazy, Lowville, Black River, and lower Trenton.^b Equivalent to Carlisle limestone and younger beds of Chazy age

GEOLOGIC HISTORY ⁴

PRE-CAMBRIAN TIME

No rocks of pre-Cambrian age are exposed in this area, but pre-Cambrian gneisses, granites, and schists overlain by lavas are exposed in the Piedmont and Blue Ridge provinces southeast of the area and form the ancient land surface on which the succeeding Paleozoic sediments were deposited. A considerable epoch of erosion intervened between the pouring out of the pre-Cambrian lava and the subsidence of the land in Cambrian time.

PALEOZOIC ERA

Cambrian period

The area was beneath sea level in the early part of the Cambrian period and into this body of water were discharged coarse sediments that formed strata of sandstone, conglomerate, and shale. A subsequent change of geographic or climatic conditions allowed the deposition of the Tomstown dolomite. All these formations crop out southeast of the area and are believed to underlie the whole area beneath the oldest formation exposed—the Waynesboro. Again the conditions of land and sea changed, and mud, sand, and fine gravel were again deposited, making the rocks of the Waynesboro formation. A period of widespread submergence followed, and great thicknesses of limestones and dolomites were deposited, some of which contain thin layers of sandstone. In central Pennsylvania these rocks are called, in order of their deposition, the Pleasant Hill and Warrior limestones, the Gatesburg formation, and the Mines dolomite. Southeast of the area they are known as the Elbrook and Conococheague limestones.

Ordovician period

The Ordovician period began with widespread submergence and deposition of a thick series of limestone and dolomite. In central Pennsylvania the Beekmantown group was deposited, comprising the Larke dolomite, Stonehenge limestone, Nittany dolomite, Axemann limestone, and Bellefonte dolomite. In Fulton County the limestones of the Beekmantown were deposited but have not been subdivided.

In central Pennsylvania emergences of the sea bottom followed both the Mines and the Larke epochs in places, while there was continued deposition in adjacent areas. Thus in Centre County and northern Blair and Huntingdon Counties, the Mines dolomite

⁴This section has been adapted in large part from Butts, Charles, U. S. Geol. Survey Geol. Atlas, Ebensburg folio (no. 133), pp. 6, 7, 1905; Hollidaysburg-Huntingdon folio (no. 227) [in press]; and Stose, G. W., U. S. Geol. Survey Geol. Atlas, Mercersburg-Chambersburg folio (no. 170), pp.15-17, 1909.

is overlain unconformably by the Stonehenge limestone (Lower Ordovician) followed by the Nittany dolomite, the Larke dolomite being absent; whereas in southern Blair and Huntingdon Counties, the Larke is conformable on the Mines but is overlain unconformably by the Nittany, the Stonehenge being absent.

At the end of Beekmantown time there was an interval during which the whole area probably stood slightly above sea level and of which there is no sedimentary record.

During the next submergence the Carlim limestone in central Pennsylvania and the Stones River limestone in Fulton County were deposited.

After Carlim time the area stood above sea level for a relatively long period while sediments were being deposited in many other parts of the United States. This emergence continued into the beginning of the Black River epoch, when widespread submergence again took place and the Black River group was deposited, comprising in central Pennsylvania the Lowville and Rodman limestones and in Fulton County the Lowville and Chambersburg limestones (in part). The deposition of limestone continued into the next epoch in central Pennsylvania, where the Trenton limestone was deposited, but in Fulton County the sediments were terrigenous rather than calcareous and formed the lower part of the Martinsburg shale (of Trenton age).

The deposition of the succeeding Reedsville shale and the remainder of the Martinsburg shale marked the beginning of a widespread change in land and sea conditions in the Appalachian region, and the shallow sea received dominantly clastic sediments until Tonoloway time. After Reedsville time the fine quartz sand of the Oswego sandstone and the sandy upper part of the Martinsburg shale were deposited, succeeded by the red sands and muds of the youngest Ordovician formation, the Juniata. The absence of fossils in the Oswego, Juniata, and succeeding Tuscarora rocks suggests that they were terrestrial deposits, or perhaps shore deposits.

Silurian period

The Silurian period began with the widespread deposition of pure quartz sand, forming the hard Tuscarora quartzite, which makes up most of the mountains in the Ridge and Valley province. In southeastern Pennsylvania the absence of the Juniata and Oswego beneath the Tuscarora indicates an emergence in that area preceding the Silurian.

The area was again submerged, and the sands and muds of the Clinton formation were deposited. The most distinguishing fea-

ture of the Clinton formation is the occurrence of beds of fossil and oolitic iron ore extending from New York to Alabama, which indicates a remarkable uniformity of conditions over a very large area.

Clinton time appears to have been followed in this area by an unrecorded interval during which the Lockport dolomite was deposited in New York and Canada, although there is some evidence that the McKenzie formation may have been laid down here during part of this interval. During the next submergence the Cayuga group was deposited, comprising the McKenzie formation, the Bloomsburg redbeds, the Wills Creek shale, and the Tonoloway limestone.

Devonian period

The Devonian period began with the deposition of the Helderberg limestone in a rather small basin, followed by the more widespread deposition of the chert, siliceous limestone, and calcareous sandstone of the Oriskany group. In the succeeding Onondaga epoch shale and limestone were deposited.

After Onondaga time a thick series of shale and some sandstone and limestone were deposited in shallow water during a long period of slow and constant subsidence of the sea floor, comprising the Marcellus, Hamilton, Tully, Portage, and Chemung units. The Catskill facies of sedimentation, commonly regarded as the deposition of continental delta materials interfingering with marine deposits, began in eastern New York during Hamilton time, and the deposition of red shales and sandstones continued contemporaneously with the marine Portage and Chemung deposition and probably extended into early Mississippian time, rising in stratigraphic position progressively westward. Thus the Catskill diminishes in thickness from several thousand feet at the east to only a few hundred feet in western Pennsylvania. In south-central Pennsylvania the dominantly red beds above the Portage or Chemung and below the Pocono are included in the Catskill formation.

Carboniferous period

Mississippian time.—Mississippian time began with the deposition of the marine and nonmarine sands of the Pocono formation, including the nonmarine (?) Burgoon sandstone member at the top. After an unrecorded interval of considerable length, the Loyalhanna limestone was laid down in certain parts of the area. The Loyalhanna, consisting of extremely cross-bedded quartzose limestone, is thought to be at least in part a wind-blown deposit of terrestrial origin.

The deposition of the prevailing gray Pocono and Loyalhanna was succeeded by another extensive deposition of red beds, locally containing beds of limestone. This formation is known as the Mauch Chunk shale and is contemporaneous with marine limestones and shales in western Pennsylvania and Ohio. Although the Mauch Chunk is several thousand feet thick at its type locality in northeastern Pennsylvania, its thickness diminishes to less than 100 feet in western Pennsylvania, and in places it is absent. These facts indicate that most of the area west of the Allegheny Front was uplifted and the Mauch Chunk was largely eroded before the deposition of the overlying Pottsville.

Pennsylvanian time.—During Pottsville time about 1,000 feet of conglomerate and sandstone containing many coal beds was deposited in eastern Pennsylvania and about 10,000 feet was deposited in Alabama. While these thick sediments were being laid down elsewhere, central and western Pennsylvania stood well above sea level and were subjected to extensive erosion but near the end of Pottsville time the land submerged and the Connoquenessing sandstone, Mercer shale, and Homewood sandstone members were deposited. In some places west of this area and in the northern part of it the Mauch Chunk and probably part of the Pocono had been completely eroded away, so that the Pottsville was deposited directly on the Burgoon sandstone.

The succeeding Allegheny epoch was one of rapidly alternating conditions resulting in the repeated deposition of shale, sandstone, limestone, and coal. The Allegheny formation contains most of the coals worked commercially in this area. It is generally believed that these coals were formed in fresh-water marshes near sea level and generally extended over thousands of square miles. Plants of various types grew luxuriantly in these marshes, and their remains accumulated as extensive peat bogs. Alternate subsidence below and emergence above sea level were repeated many times, so that numerous beds of coal with their under clays were accumulated, with intervening beds of shale, sandstone, and limestone.

A marked change in the conditions of vegetation and sedimentation followed Allegheny time, and a thick series of sandstones, shales, and locally thin limestones composing the Conemaugh formation was laid down. Brief recurrences of coal-forming conditions occurred throughout this period of deposition, but the coals thus formed are generally too thin to be of widespread commercial value.

The Conemaugh epoch was succeeded by the deposition of the Monongahela formation, which was marked by another great period of coal formation and a series of events similar to those outlined for the Allegheny formation. The Monongahela formation has been eroded from this area, except for thin remnants in Cambria and Somerset Counties and perhaps in the Broad Top coal field.

Permian time.—The Monongahela epoch was succeeded by the deposition of the shales, sandstones, limestones, and thin coals of the Dunkard group, which have been entirely removed by erosion from the area covered by this report, except possibly from the higher parts of the Broad Top coal field, although their presence there appears to be highly doubtful.

GEOLOGIC STRUCTURE

The Dunkard epoch ended sedimentation in this area, and an uplift of the sea bottom followed, accompanied by a period of strong lateral deformation known as the Appalachian uplift or revolution, by which the originally horizontal sediments were highly folded and somewhat faulted.

During the Appalachian uplift the flat-lying Paleozoic rocks from the southeastern border of the area to the Allegheny Front were subjected to extreme lateral compression, but the effect of this deformation gradually died out west of the Allegheny Front. As the compression increased the strata were more intensely folded, and the upfolds or anticlines rose higher and steeper and in some places were overturned toward the northwest. In some places the once horizontal beds now stand nearly vertical or are actually overturned. As some of the folds were overturned, they were broken and one part overrode another, sometimes for considerable distances. East of the Allegheny Front the rocks have been folded into numerous high anticlines and deep synclines, with the oldest formations exposed in the anticlines and the youngest formations exposed in the synclines. West of the Allegheny Front the rocks have been folded into low anticlines and synclines in some places but remain nearly horizontal in other places. Subsequent erosion has developed a relief closely accordant with the occurrences of hard and soft rocks, so that the general structure of the area can be recognized in the present-day topography, as shown in plate 3 and in the cross section in plate 1.

After determining the dip of the strata at numerous places along the Juniata and Susquehanna Rivers, Chamberlin⁵ con-

⁵ Chamberlin, R. T., The Appalachian folds of central Pennsylvania: Jour. Geology, vol. 18, p. 235, 1910.

cluded that 81 miles of once horizontal strata had been compressed into the present distance of 66 miles between Harrisburg and Tyrone, which gives a total crustal shortening of 15 miles between these two points.

Space does not permit a discussion of all the numerous folds and faults in the area, but some of the major features are mentioned below and in the county descriptions and the relation between geologic structure and the occurrence of ground water is discussed on pages 40-41.

Ridge and Valley province.—The principal structural features in the Ridge and Valley province are a series of anticlines and synclines trending from about N.25°E. in the southwestern part to about N.75°E. along the Susquehanna River. Except for the deep Broad Top syncline, high anticlines predominate throughout most of the area, dying out gradually northeastward toward the Susquehanna River, east of which the deep anthracite synclines of northeastern Pennsylvania begin to predominate. The deep Lackawanna syncline, enclosing the northern anthracite field, is a northeastward extension of the deep syncline which encloses the Broad Top coal field at the junction of Huntingdon, Bedford, and Fulton Counties.

The largest of these folds is the Nittany arch, which extends for about 150 miles from southern Bedford County northeastward to the Susquehanna River near Williamsport and attains a width of about 35 miles near Altoona. The sandstones of the Pocono and Pottsville formations on the northwest limb of this large arch form the Allegheny Front. Butts and Moore⁶ have estimated that if the strata that had been eroded from the crest of this arch in Nittany Valley and Morrison Cove were restored, the resulting mountain would be 5 miles high. The Nittany arch is really a large anticlinorium containing numerous minor folds and traversed by faults of considerable magnitude. A view of one of the minor folds within the Nittany arch is shown in plate 7, A.

Nearly all the folds in this province are asymmetric—that is, the northwest limbs of the anticlines have steeper dips than the southeast limbs—and the principal faults of the area dip southeast. The strata on the northwest flanks of some of the anticlines stand vertical or are overturned.

There are in the area several characteristic Appalachian thrust faults, which trend parallel to the strike of the strata, and a few minor cross faults, which cut across the strike. The thrust at Birmingham in Blair and Centre Counties has a stratigraphic

⁶Butts, Charles, and Moore, E. S., *Geology and mineral resources of the Bellefonte quadrangle, Pennsylvania*: U. S. Geol. Survey Bull. 855, p. 80, 1936.



A. Glass-sand quarry in Ridgeley sandstone of the Oriskany group north of Mapleton, Huntingdon County. The beds of pure white sandstone dip steeply toward the observer.



B. Quarry in Ordovician limestone along Elk Run 1 mile west of Ironville, Blair County.



A. Small faulted anticline in the Portage group, along Pine Creek about 0.3 mile north of Highway 220, Lyscoming County. Note openings suited as conduits of ground water.



B. Observation well 555, near Petersburg, Huntingdon County, showing measuring point and steel tape and weight.

displacement of about 5,000 feet.⁷ The thrust faults at Halter Creek, Williamsburg, and Henrietta traverse parts of Blair and Bedford Counties, and the stratigraphic displacement along the faults at Halter Creek and west of Henrietta is also about 5,000 feet.⁸ About 9,000 feet of strata have been cut out by the thrust faults at McConnellsburg and Little Scrub Ridge in eastern Fulton County.⁹

Appalachian Plateaus province.—The Appalachian Plateaus province is limited on the southeast by the northwest limb of the Nittany arch which is succeeded on the northwest by a series of synclines, which enclose the bituminous coal basins, and intervening anticlines. The synclines and many of the anticlines are known by different names in the several plateau counties, but there are several rather pronounced anticlines which extend for long distances. The Chestnut Ridge anticline is one of the strongest folds of the plateaus, extends through Fayette, Westmoreland, and Indiana Counties, and enters the area here described in Clearfield County. Another pronounced fold is the Laurel Hill anticline, which forms a high ridge through much of its length. The Laurel Hill anticline coincides with the western boundary of the area in Somerset County and southern Cambria County. The Negro Mountain anticline, in Somerset County, forms the highest mountain in the State (see page 10).

There are relatively few faults in the rocks of the Appalachian Plateaus province, and these are principally in southwestern Clearfield County.

MESOZOIC AND CENOZOIC ERAS

No part of the area described in this report has been beneath the sea since Carboniferous time, and its rocks have been subjected to erosion during all of the Mesozoic and Cenozoic eras. In adjacent southeastern Pennsylvania narrow belts of land sank with respect to adjacent blocks in late Triassic time, and red sandstone and shale were deposited in these sinking troughs. Also during Triassic time molten basaltic igneous rock intruded the Triassic and older sediments, and some of these Triassic diabase dikes cut through the Paleozoic sediments of eastern Perry County.

Most physiographers have held that erosion has not progressed uniformly in the area since the Appalachian uplift but has varied

⁷ Butts, Charles, Geology and mineral resources of the Tyrone quadrangle, Pennsylvania: Unpublished manuscript.

⁸ Butts, Charles, U. S. Geol. Survey Geol. Atlas, Huntingdon-Hollidaysburg folio (no. 227) [in press].

⁹ Stose, G. W., U. S. Geol. Survey Geol. Atlas, Mercersburg-Chambersburg folio (no. 170), p. 5, 1909.

in intensity as the land rose, sank, or remained stationary with respect to sea level. There appears to have been at least one prolonged halt in the general rise of the land, during which the land surface was worn down to a gently sloping plain near sea level, called a peneplain. The reduced remnants of this old surface, called the Kittatinny or Schooley peneplain, are strikingly reflected in the flat, even crests of the high sandstone ridges in the Ridge and Valley province, the Allegheny Front, and the highest parts of the Appalachian Plateaus province. Although the long period of erosion that produced this peneplain was sufficient to reduce both hard and soft rocks alike to a nearly featureless plain, subsequent erosion of much shorter duration wore down the softer rocks rapidly but had much less effect on the hard rocks, which remain as long even-crested ridges, as shown in plates 3 and 4, B. The major streams of the area are believed to have taken their meandering courses on this peneplain and have since maintained these courses and cut the numerous water gaps through high ridges of hard rock, while the smaller streams eroded the softer rocks between the ridges.

According to most physiographers, this old peneplain was formed during Jurassic or possibly early Cretaceous time, and subsequent uplifts during the Tertiary have formed several younger peneplains or partial peneplains. For example, the valley-floor surface of the broad, rolling lowland of the Ridge and Valley province is regarded as representing the Harrisburg peneplain, of early Tertiary age, and terraces along the major streams are regarded as later partial peneplains.

In contrast to these views, Ashley ¹⁰ has recently expressed the view that the oldest peneplain (Schooley) may be of late Pliocene age and therefore possibly only one or two million years old. He concludes further (1) that the present surface reflects but a single old peneplain "that has been lowered by not less than 100 feet for the hardest rocks, and by several hundred feet for the softer rocks, for each million years since the beginning of uplift; (2) that, except near the Atlantic coast and during recent time, all the level surfaces and [restored] imaginary surfaces touching the tops of accordant hills and mountains may be accounted for by (a) local baseleveling or district baseleveling, or (b) by the stripping of flat-lying or nearly flat-lying hard rocks, or (c) as the result of parallel lowering because of uniformity of rock and structure; (3) that, as a rule, subsequent trenching has been the result of stream capture or the undercutting of a resis-

¹⁰ Ashley, G. H., *Studies in Appalachian Mountain sculpture*: Geol. Soc. American Bull., vol. 46, p. 1436, September 30, 1935.

tant layer in the barrier arch or syncline, or of other stream adjustments not associated with crustal movements; (4) that the detailed underlying geology must be known and be taken into account if reliable conclusions about physiographic history are to be drawn; and (5) that most physiographic features are much younger than most physiographers have assumed.¹¹

In the Pleistocene epoch northern Pennsylvania was covered several times by great ice sheets from the north, some of which reached the northeastern part of the area here described, where glacial deposits occur, but the rest of the area was not covered by the ice. However, the swollen streams that issued from the retreating glaciers carried gravel, sand, and silt southward into part of the area.

In the Recent epoch down-cutting of the streams has continued, the sculpturing of the area has brought it to its present topographic form, and deposits of alluvium have been laid down along some of the streams.

GROUND WATER

SOURCE

Ground water, or underground water, is the water that issues from springs or can be pumped from wells. The ground water of central and south-central Pennsylvania is derived almost entirely from precipitation in the form of rain or snow. Part of the water that falls as rain or snow is carried away directly to the ocean by the streams; part of it percolates downward into the rocks until it reaches the water table, where it joins the body of ground water known as the zone of saturation; and part of it evaporates or is absorbed and transpired by the vegetation before it reaches the water table.

The ground water percolates slowly through the rocks in directions determined by the topography and geologic structure, until eventually it is discharged through wells or springs; seeps into the streams; or is lost by evaporation and transpiration in lowlands bordering the streams. In some parts of the United States the water obtained from wells has traveled many miles from the area of intake, but in central and south-central Pennsylvania the water obtained from shallow wells and springs is generally derived from precipitation in the immediate vicinity, and the water obtained from the deeper wells is derived from precipitation in the general vicinity—usually within the same or an adjacent county.

¹¹ *Idem*, p. 1398.

In addition to water derived from precipitation (meteoric water) some of the rocks still contain some sea water which was entrapped in them at the time of their deposition (connate water). Saline water of this type is encountered in a few deep wells in parts of the Appalachian Plateaus province.

Many of the residents of this area mistakenly attribute the source of the water in their springs or wells to far distant lakes or rivers. For example, in Nittany Valley, Centre County, some of the residents believe that the water discharged by the large limestone springs comes from Lake Erie, Lake Cayuga, or some other lake in New York State. It should be emphasized however, that there are many thousands of feet of impervious strata between Nittany Valley and New York State, and that the surface of Nittany Valley, which is 800 to 1,300 feet above sea level in most places, stands at a considerably higher altitude than the surface of any of these lakes. Other residents of the area believe that the ground water comes from nearby streams. This is partly true in the valleys underlain by limestone, where numerous small streams enter the ground through sink holes, but in humid areas the streams generally do not lose water into the ground and almost invariably receive water from the ground.

Some of the residents of the area do not believe that the amount of water falling as rain or snow is sufficient to supply the large underground reservoirs. However, 1 inch of water falling on 1 square mile amounts to more than 15,000,000 gallons, and the average precipitation in the area is about 40 inches, or approximately 600,000,000 gallons to the square mile. Part of this water reaches the underground reservoirs, as described above. The relation between the water level in wells and the precipitation is described on pages 35-40.

OCCURRENCE ¹²

STORAGE AND MOVEMENT

The rocks forming the outer crust of the earth are generally not entirely solid but contain numerous openings, called voids or interstices, which may contain either liquid or gas, such as water, oil, natural gas, or air. There are many kinds of rocks, and they differ in the number, size, shape, and arrangement of their interstices and hence in the amount of water they are able to hold. The occurrence of ground water in any region is therefore determined by the geology.

¹² For detailed treatment of the occurrence of ground water, see Meinzer. O. E., *The occurrence of ground water in the United States, with a discussion of principles*: U. S. Geol. Survey Water-Supply Paper 489, 321 pp., 110 figs., 31 pls., 1923.

The voids or interstices in rocks range in size from microscopic openings to the large caverns found in limestone regions and may be classified according to their origin into primary and secondary interstices, according to whether the interstices were formed contemporaneously with the formation of the rock or by processes that affected the rock after it was formed. In this area the water-bearing rocks are all of sedimentary origin, and the openings that contain water are the pore spaces between the grains of the rocks; the joints, crevices and open bedding planes that have resulted from fracturing of the rocks; and channels or caverns in limestone and dolomite, which have resulted from the solution and corrosion of the rocks by water moving along the joints or bedding planes. The last two kinds of openings are the most important conduits of ground water in central and south-central Pennsylvania.

The amount of water that can be stored in any rock depends on the porosity of the rock, commonly expressed as the percentage of the total volume of the rock that is occupied by interstices. A rock is said to be saturated when all its interstices are filled with water. Several types of rock interstices and the relation of rock texture to porosity are shown in figure 3.

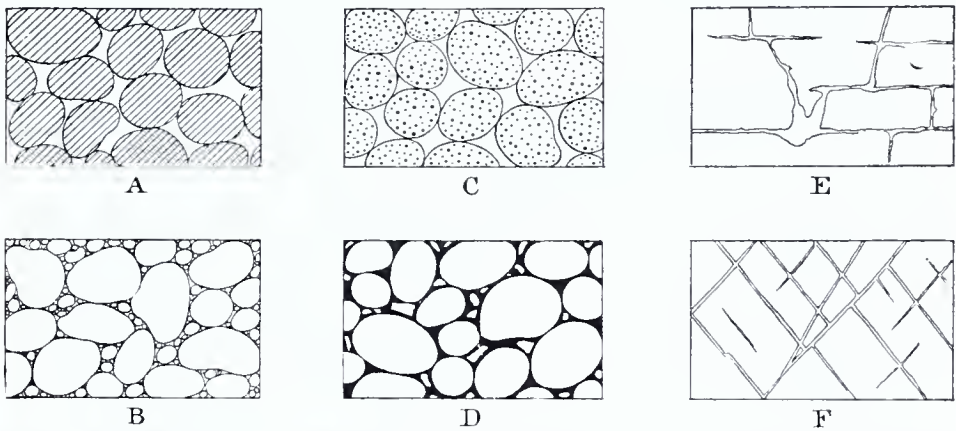


Figure 3. Diagram showing several types of rock interstices and the relation of rock texture to porosity. A, Well-sorted sedimentary deposit having a high porosity; B, poorly sorted sedimentary deposit having a low porosity; C, well-sorted sedimentary deposit consisting of pebbles that are themselves porous, so that the deposit as a whole has a very high porosity; D, well-sorted sedimentary deposit whose porosity has been diminished by the deposition of mineral matter in the interstices; E, rock rendered porous by solution; F, rock rendered porous by fracturing. (After Meinzer.)

Porosity alone determines only how much water a given rock can hold, not how much it may yield to wells. The permeability of a rock may be defined as its capacity for transmitting water under the force of gravity and is measured by the rate at which it will transmit water through a given cross section under a given

difference of pressure per unit of distance. A bed of silt or clay may have as high a porosity as a bed of coarse sand, but because of the small size of its interstices it may require the application of great pressure to transmit water, and hence, under the incompetent force of gravity, it may be entirely impermeable. Moreover, not all the water in a saturated rock is available to wells, because part of the water is held against the force of gravity by molecular attraction. In a fine-grained rock the molecular attraction is very great and only a small part of the water can be drained out by the force of gravity, whereas in a coarse sand or gravel having the same porosity only a small part is retained by molecular attraction and the remainder becomes available to wells.

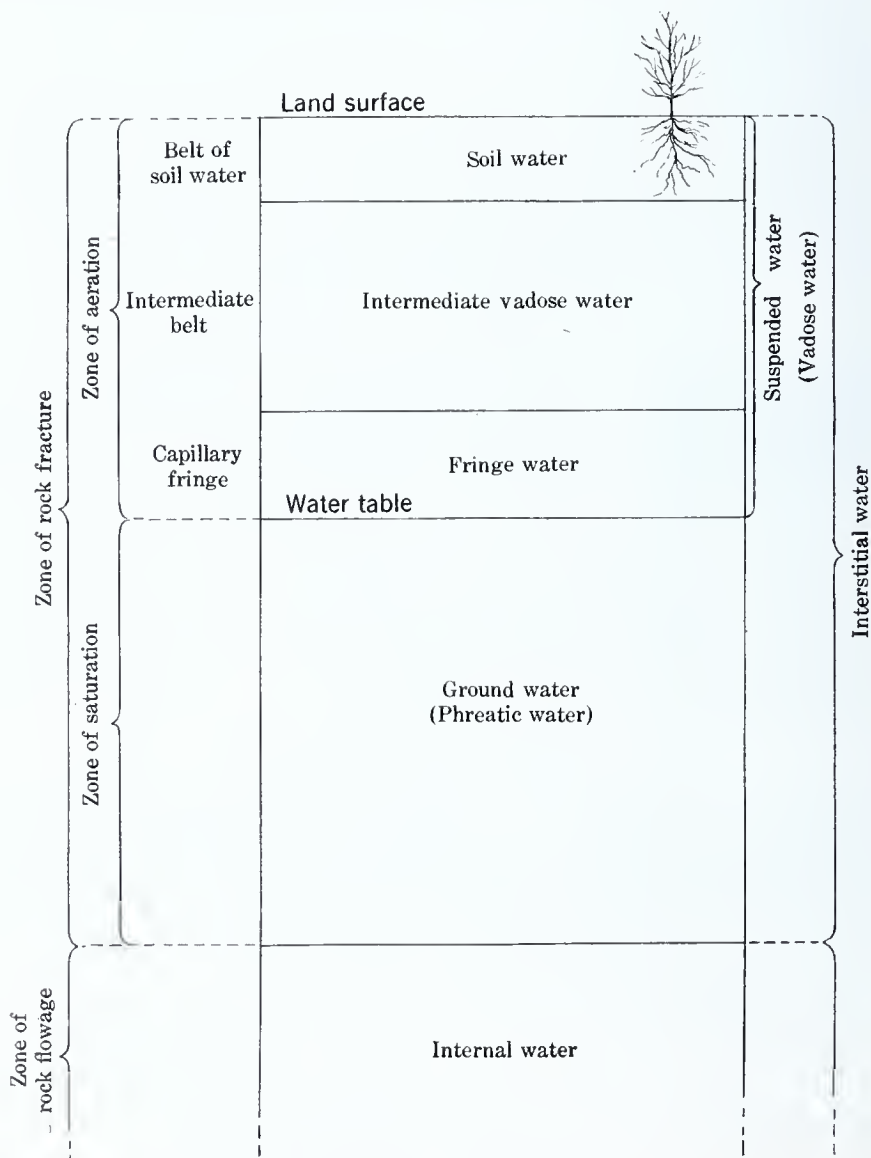


Figure 4. Diagram showing divisions of subsurface water. (After Meluzer.)

WATER TABLE

The permeable rocks that lie below a certain level in this area are generally saturated with water. These saturated rocks are said to be in the zone of saturation, and the upper surface of the zone of saturation is called the water table. The relation of the zone of saturation to the zone of aeration is shown in figure 4. The water that falls on the soil is slowly drawn down by gravity through the zone of aeration to the zone of saturation, except that which is retained by molecular attraction. In fine-grained materials, owing to capillarity, the earth is always moist several feet above the water table, and this moist belt is called the capillary fringe. The water retained in the capillary fringe is not available to wells, which must be sunk to the water table before water enters them.

Perched water

Where permeable rock is homogeneous down to a considerable depth there is only one zone of saturation, but in some localities the water may be hindered in its downward course by a relatively impermeable bed and form an upper zone of saturation known as a perched water body. Bodies of perched water occur in some parts of the area. Well 57, in Clearfield County, encounters the water table beneath a hillside in shale at a depth of about 30 feet, whereas in several shallow dug wells nearby a perched water table stands within a few feet of the surface. Bodies of perched water doubtless occur locally in the thick blanket of soil and residual clay that overlies the rock in the limestone valleys.

Relation to topography

In central and south-central Pennsylvania some of the water from the rain and snow commonly percolates to the water table throughout the interstream areas. Hence the water table is an undulating surface, which generally stands higher beneath the upland areas than beneath the adjacent valley areas and which slopes gradually down to the level of the streams. As the ground water is under hydrostatic pressure, the movement is toward the streams, so that except at flood stages the streams are commonly gaining water from the zone of saturation. A depression in the land surface that intersects the water table may produce springs of the type known as depression springs. Other types of springs common in the area are discussed on page .

Fluctuations

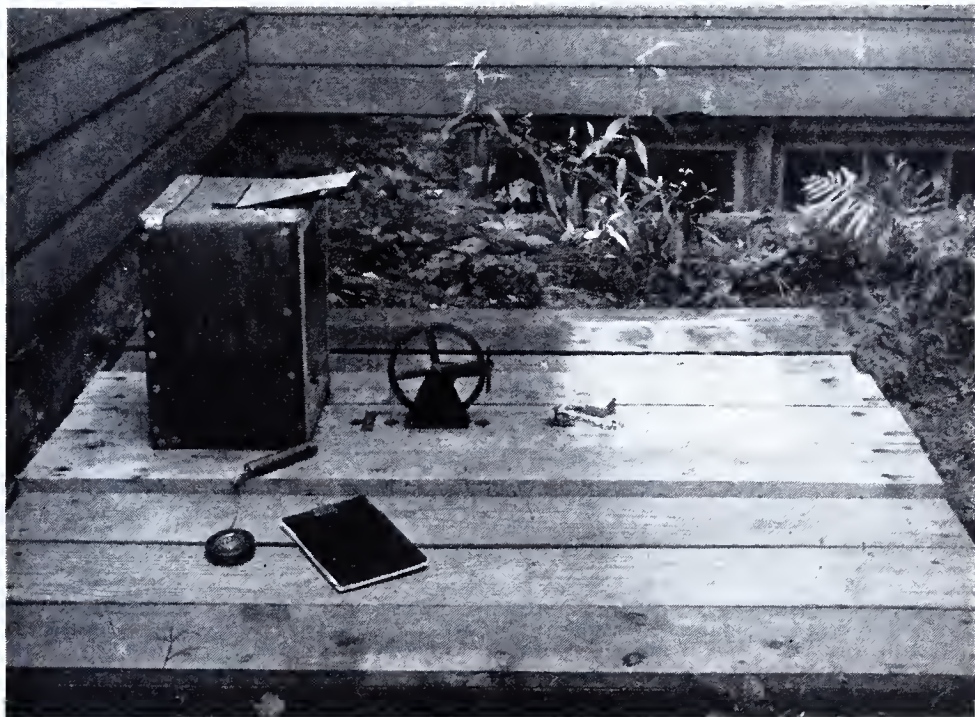
There is a relation between the amount of water falling as rain or snow and the level at which the water stands in wells, but this relation is complicated by several factors. Other things being

equal, the greater the precipitation for a given period the greater the rise in the water level. However, after a prolonged dry spell the moisture contained in the soil becomes depleted, and when rain occurs it must first replenish the soil moisture before the water can percolate down to the water table. The temperature also has an influence, for rain that falls on frozen ground is hindered appreciably from reaching the water table, and part of the water that falls during the hot summer is evaporated directly into the air. With the coming of spring the vegetation begins to make heavy demands on the soil moisture, and in some places where the tree roots extend down to the water table the trees draw water directly from the zone of saturation. Thus, although the rainfall is greater during the summer, the water table generally declines because of the heavy consumption of water by vegetation. When the first killing frost occurs in the fall, the consumption of water by vegetation nearly ceases, and even though there may be no appreciable precipitation, the water level in wells on lowlands may rise somewhat, and small springs may increase in flow. During the winter, at times when the ground is not frozen, the precipitation can percolate downward with little loss from evaporation and transpiration, and after the soil moisture has been replenished a moderate amount of precipitation may cause an appreciable rise in the water table. The fluctuations of the water table are also dependent upon other factors, including the type of water-bearing material, the topography, and the depth to water. There is also a relation between the height of the water table and the flow of the streams, which is chiefly supplied by ground water except at times when there is direct run-off from rain or melting snow.

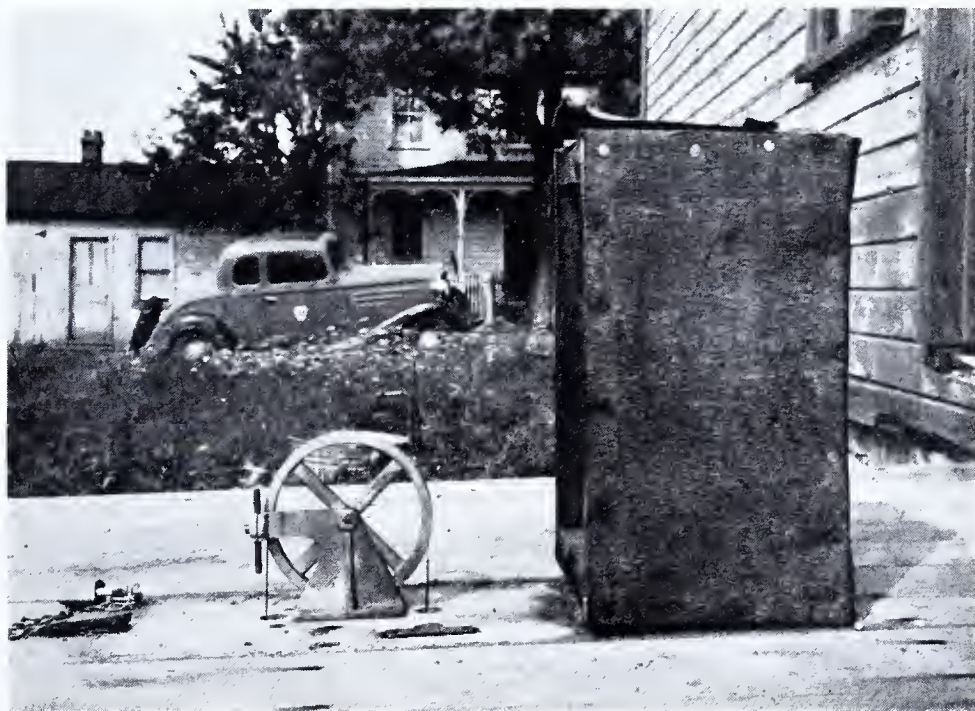
In the fall of 1931 a project was begun for obtaining systematic weekly records of ground-water levels in Pennsylvania, in cooperation between the United States Geological Survey and the Pennsylvania Topographic and Geologic Survey.¹³ The complete records for all wells that were being observed at the end of 1936, including 9 observation wells in the area covered by the present report, together with the average weekly water levels for all observation wells in Pennsylvania, have recently been published,¹⁴ and future well records will be published in similar annual reports. Four other observation wells in the area were measured for several years, but the measurements have been discontinued.

¹³ Water levels and artesian pressure in observation wells in the United States in 1935: U. S. Geol. Survey Water-Supply Paper 777, pp. 161-169, 1936.

¹⁴ Water levels and artesian pressure in observation wells in the United States in 1936: U. S. Geol. Survey Water-Supply Paper 817, pp. 260-301, 1937.

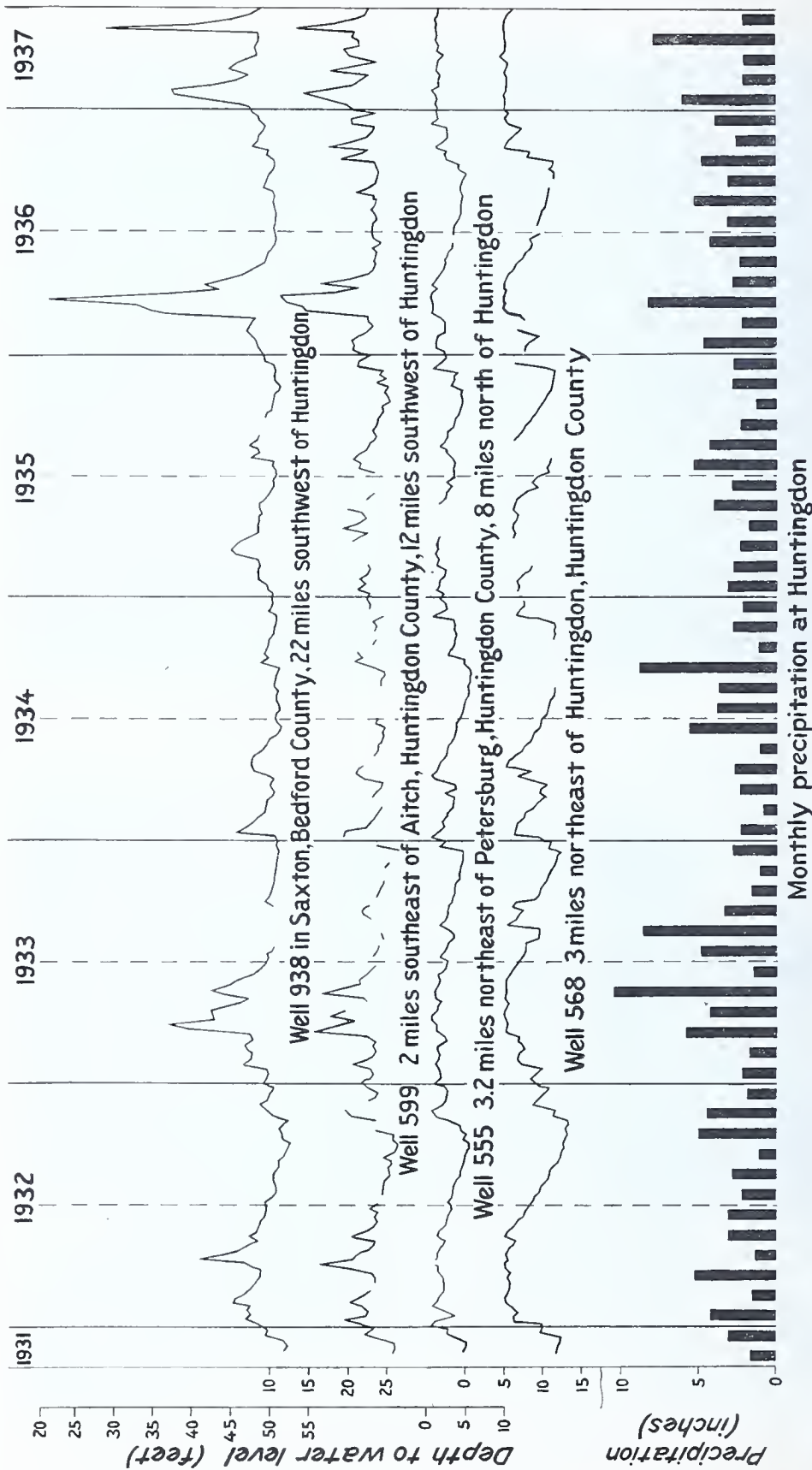


A. Well 822, at Newport, Perry County.



B. Well 938, at Saxton, Bedford County.

OBSERVATION WELLS EQUIPPED WITH KINNISON FLOAT GAGES



Graphs showing the precipitation and the fluctuations of the water levels in four observation wells in Huntingdon and Bedford Counties. Wells are described by number in the county descriptions, and their locations are shown on plate 2. Precipitation data from U. S. Weather Bureau.

The location, period of record, and publication numbers for all observation wells in this area are listed in the following table.

Observation wells in south-central Pennsylvania

County	Well no. in this report	Well no. in Water- Supply Paper 817	Period of record	Remarks
Bedford.....	985	.....	Nov. 1931 to Oct. 1934.....	Discontinued.
Do.....	938	45	Nov. 1931 to present time ¹ ...	See plates 8, 9.
Centre.....	166	38	Do.....	
Clearfield.....	32	.....	Nov. 1931 to Aug. 1936.....	Discontinued.
Do.....	77	111	Aug. 1936 to present time....	
Do.....			Nov. 1931 to Aug. 1936.....	0.5 mile NE. of well 77; discontinued.
Huntingdon....	555	50	Nov. 1931 to present time....	See plates 7, 9.
Do.....	568	49	Do.....	See plate 9.
Do.....	599	47	Do.....	Do.
Juniata.....	750	.....	Nov. 1931 to Nov. 1932.....	Discontinued.
Perry.....	782	110	July 1936 to present time....	
Do.....			Nov. 1931 to July 1936.....	1.2 miles NE. of well 110; discontinued.
Do.....	822	61	Nov. 1931 to present time....	See plate 8.
Somerset.....	901	16	Do.....	

¹ June 1937 and thereafter.

Most of these are unused shallow dug wells, but nos. 77 and 599 are unused drilled wells. The depths to water level in these wells are measured weekly to the nearest hundredth of a foot by local observers. Most of them are measured by lowering into the well a steel tape with a weight attached as shown in plate 7, B, but some are equipped with direct-reading float gages, as shown in plate 8.

The fluctuations of the water table in four observation wells in Huntingdon and Bedford Counties and the precipitation at Huntingdon are shown in plate 9. In wells 555 and 568 the maximum height to which the water may rise appears to be limited—in well 555 by the ground surface and in well 568 by a natural escape through an old excavation at a depth of about 6 feet. In contrast, in wells 599 and 938 the water table stands farther below the ground surface, and its maximum rise does not appear to be likewise limited.

As shown in plate 9, the water levels generally stand highest in March or April, at the period of maximum winter recharge. The lowest water levels are generally reached near the end of the growing season, in September or October, although some-

times the water levels continue to decline as late as November or December, as in well 568 in 1933 and 1935.

The normal summer declines in 1933 and 1934 were arrested by abnormally heavy rains in August 1933 and September 1934, and hence the lowest water levels reached in those years were considerably higher than the minima for the other years of record.

The combination of weather conditions that produced the record-breaking floods of March 1936¹⁵ raised the ground-water levels on March 21 in most of the observation wells to the highest stage reached during the 5½ years of record. This is illustrated in plate 9 by the high stages reached in wells 938 and 599 on March 21. The water levels in wells 555 and 568 could rise no higher in 1936 than in other years, for the reasons stated above.

The first part of January 1936 was relatively mild and had several rains that produced slight rises in the water table. During the later part of January and most of February the weather was characterized by unusually heavy snowfall and unusually low temperatures, hence there was little or no ground-water recharge during this period. A general thaw began about February 25 and continued to the beginning of the flood period in March. The melting of part of the snow and frost apparently released considerable water downward to the water table, producing considerable ground-water recharge by March 1, when the ground-water levels were still rising rapidly. This rapid rise indicates that there probably was considerable water in transit within the zone of aeration, though not enough to produce complete saturation. The additional water derived from the heavy rains that produced the floods appears to have been sufficient to complete the saturation of a considerable part of the zone of aeration, which greatly accelerated the rise of the water table. Thus a large part of the recharge at the time of the floods appears to have come from the water which was already in the zone of aeration and which was derived from the snow that fell some time before the floods.

The heavy precipitation at the time of the great Ohio River flood also produced abnormally high ground-water levels in the latter part of January 1937. The highest stages reached in this

¹⁵ The floods of March, 1936, part 2, The Hudson River to Susquehanna River region: U. S. Geol. Survey Water-Supply Paper 799, 380 pp., 49 figs., 1937. The floods of March 1936, part 3, The Potomac, James, and upper Ohio Rivers: U. S. Geol. Survey Water-Supply Paper 800, 346 pp., 57 figs., 1937. The floods of March 1936 in Pennsylvania: Commonwealth of Penna., Dept. of Forests and Waters, 123 pp., 4 pls., 31 figs., Sept. 19, 1936.

area in 1937, however, were reached about May 1, as a result of heavy rains in April.

Despite the exceptionally high stage in March 1936, the water levels in most wells declined persistently during the spring and summer of that year, until by the later part of September the lowest average stage was reached since 1932. This great decline from the highest stage nearly to the lowest of record resulted from the fact that from April to September the precipitation was too light to produce any appreciable recharge except a small amount in August. In material of rather low specific yield, such as comprises most of central and south-central Pennsylvania, the water table may decline rapidly unless there is frequent recharge from rainfall.

The water flowing in the streams during periods of dry weather is practically all ground water that has escaped from springs or seeps; hence as the ground-water levels in wells decline during the summer, so also does the stream flow decline. Thus the flow of the streams in this area reached very low stages during the summer and fall of 1936, and the low ground-water levels and stream flow reached by fall were in part the result of conditions that existed prior to May 15 and were in a measure forecast by the ground-water levels on that date.

As the water discharged by springs in the area represents water that escapes from the zone of saturation, the discharge of springs also fluctuates in response to precipitation and other factors. Some residents of the large limestone valleys in the area where large springs occur believe that the discharge of such springs is

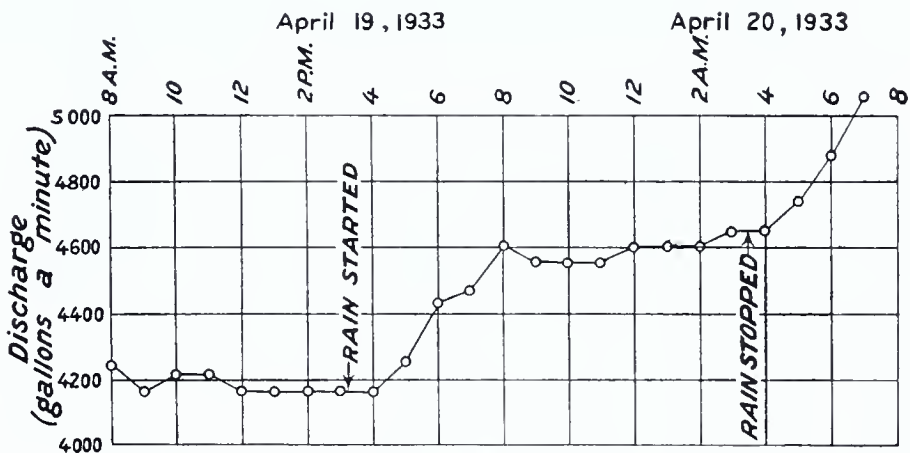


Figure 5. Discharge of Thompson Spring (no. 165) at State College, Centre County, during 23-hour period from 8 a. m. April 19 to 7 a. m. April 20, 1933. Rain amounting to 0.97 inch fell between 3:15 p. m. April 19 and 2:30 a. m. April 20. Note continued increase in discharge after rain stopped. Measurements made by Ralph R. Cleland, sanitary engineer, Department of Grounds and Buildings, Pennsylvania State College. (See pl. 10.)

absolutely constant, but if these springs were observed carefully throughout the year it would be found that the discharge is not constant and in nearly all springs varies considerably from winter to summer. The discharge of Thompson Spring (no. 165), owned by the Pennsylvania State College, at State College, Centre County, was measured over a period of about 2½ years by Ralph R. Cleland, sanitary engineer, of the Department of Grounds and Buildings, and these measurements together with the local daily precipitation are shown graphically in plate 10. Hourly measurements of the discharge during and after a single rainstorm are shown graphically in figure 5.

RELATION TO GEOLOGIC STRUCTURE

In many of the rock formations in central and south-central Pennsylvania strata of permeable rock, such as fractured sandstone, alternate with less permeable beds, such as shales. In places where strata are tilted, water falling on the outcrop area of a permeable stratum moves down the dip between the confining layers of impermeable material and saturates the permeable stratum nearly to the surface. Under these conditions wells drilled to the water-bearing beds may encounter water which is under artesian pressure—that is, water which rises above the local water table. If the water rises high enough to flow at the surface the well is a flowing artesian well. The chief requisite conditions for artesian wells are shown in Figure 6.

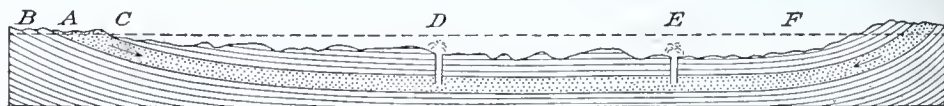
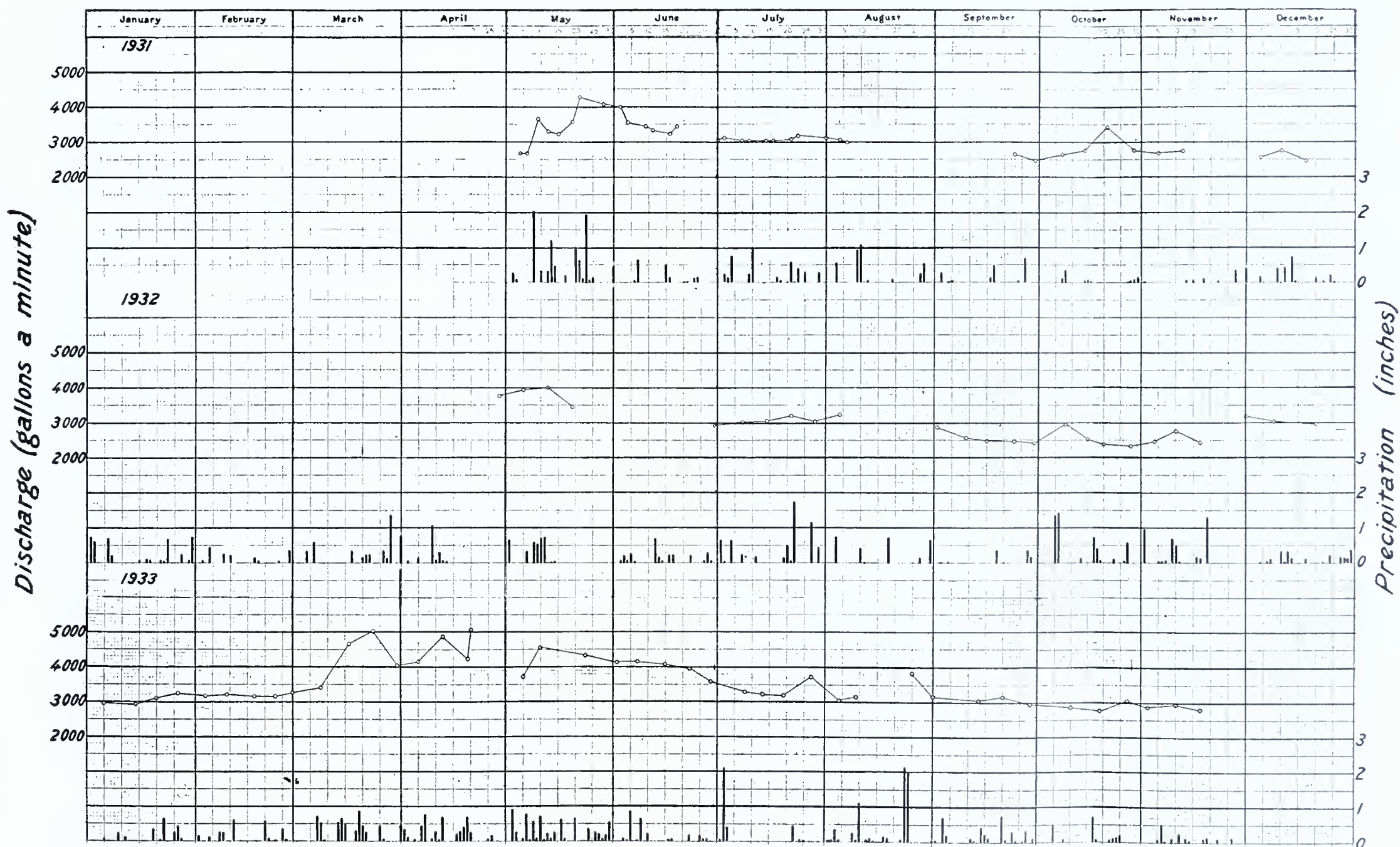


Figure 6. Ideal section illustrating chief requisite condition for artesian wells. A, Permeable bed; B, C, impermeable beds below and above A; D, E, flowing wells from bed A; F, height of water level in permeable bed A. (After Chamberlin.)

Structural features for artesian conditions in this area are synclinal basins (fig. 6), in which the strata on all sides dip toward a common axis or center, and the flanks of anticlines, where the strata dip away from the anticlinal axis. Forty-six wells that flow all or part of the year were observed or reported in the area, as shown on plate 2. Although structure favorable for flowing wells occurs in both the Ridge and Valley and the Appalachian Plateaus provinces, flowing wells are more numerous and have greater yields on the plateaus than in most parts of the Ridge and Valley province. Perhaps the greater deformation to which the rocks of the Ridge and Valley province have been subjected has ruptured the confining beds in most places, so that any water



Graph showing the discharge of Thompson Spring (no. 165) at State College and the daily precipitation at State College, Centre County. Owned by Pennsylvania State College; described by number in description for Centre County. Discharge measurements made by Ralph R. Cleland, sanitary engineer, Department of Grounds and Buildings, Pennsylvania State College. Precipitation from U. S. Weather Bureau. See figure 5.

that normally would be held under pressure beneath them escapes upward to the water table.

Wells 1 and 31, in Clearfield County, and well 97, in Centre County, were observed to flow about 40 gallons a minute during the summer of 1934, and well 925, in Somerset County, has a reported flow of about the same amount. Most of the other flowing wells flow at rates ranging from less than 1 gallon to about 15 gallons a minute. In most of these wells the water if confined would rise only 1 or 2 feet above the ground surface, but wells 31 and 429 have reported static water levels of 10 and 15 feet respectively above the ground surface. Some of the wells flow continuously, but generally have larger flows during the winter and spring. Others flow only during the winter and spring. Well 232, in Clinton County, is a flowing well that obtains its water from gravel confined beneath clay, but all the other flowing wells described are in consolidated rocks.

Many of the nonflowing wells are artesian in that the water level stands above the local water table, and in many of the non-artesian wells the water rises above the point at which it was encountered by the drill.

The occurrences of flowing wells and locations of areas where such wells might be expected are given in the county descriptions.

WATER IN UNCONSOLIDATED DEPOSITS

Gravel and sand are among the most productive water-bearing materials. In the northern part of the area a few valleys are underlain by rather thick deposits of clay, sand, and gravel, and thinner and less extensive deposits of these materials occur along the Susquehanna River at the eastern border of the area and locally along the Juniata River. The location, age, character, and thickness of these deposits are given on pages 119-122.

Most of the clay, sand, and gravel was laid down in the valleys by fluctuating streams as alluvium or, at the north, as glacial outwash, but in a few places lake deposits and glacial drift occur. At one time a stream may deposit clean, coarse gravel and shortly afterward only sand, silt, or clay, some of which may fill the interstices of the gravel. Some of the heavily burdened glacial streams deposited mixtures of clay, sand, and gravel, so that the spaces between pebbles were filled with finer materials, which greatly reduced the porosity. As the streams aggraded their valleys they probably migrated from side to side across the valleys so that at any one locality well-sorted sand or gravel alternates with finer, less permeable materials. Thus the unconsolidated deposits in the area consist largely of layers of fine

particles of low permeability that enclose pipes and discontinuous sheets of permeable gravel or sand, which serve as arteries of ground water. The development of ground water in these deposits therefore depends upon encountering one or more of these gravel or sand layers. Where coarse and fine materials occur together, the yield of a well can be materially increased by removing the fine particles from the vicinity of the well, as described on page 58.

As the thickest and most extensive unconsolidated deposits of the area have not been developed beyond the needs of domestic consumption, their maximum water-yielding capacity can only be estimated. A dug well (no. 216, Clinton County) 18 feet deep that ends in gravel yields 150 gallons a minute and was reported to yield 1,000 gallons a minute on a test for 4 hours, but the draw-down at this pumping rate is not known. Over most of the area the unconsolidated deposits are probably not capable of yielding large supplies of water, but in a few places, described on page 121, as much as 1,000 gallons a minute might be obtained from properly constructed drilled wells using screens.

WATER IN SANDSTONE, CONGLOMERATE, AND QUARTZITE

Beds of sandstone are numerous in most of the rock formations of central and south-central Pennsylvania; beds of conglomerate and quartzite are less common. The numerous Carboniferous sandstones are the most productive water-bearing rocks in that part of the area lying in the Appalachian Plateaus province, and among them those of the Pottsville formation are probably the most productive. In the Ridge and Valley province the most productive water-bearing sandstones occur principally in the Clinton, Oriskany, Hamilton, Chemung, Catskill, and Pocono rock units, but sandstones of less yield occur also in the Gatesburg, Oswego, Juniata, Tuscarora, and Portage units. The Ridgeley sandstone of the Oriskany group is probably the most productive sandstone in the Ridge and Valley province and ranks second only to the limestones and dolomites.

The size of grain, degree of assortment, amount and character of cementation, and amount of jointing are the principal factors that determine the water-bearing properties of a sandstone or conglomerate, and jointing is the most important factor in a quartzite. All the quartzites and with few exceptions all the conglomerates and sandstones appear to be firmly cemented, so that in general their porosities are probably rather low. Those cemented with silica (SiO_2) or iron oxide (Fe_2O_3) generally retain most of their cementing material even in weathered out-

crops, but those cemented with calcium carbonate (CaCO_3), such as the Ridgeley sandstone, may lose all or much of their cementing material down to appreciable depths through leaching by vadose or ground water, leaving loose, poorly consolidated sand. Joints in sandstone of this type may be enlarged by solution similar to those in limestone. (See "Water in limestone and dolomite," page 46.)

The porosity of two samples of sandstone collected from the area and the coefficient of permeability ¹⁶ of one of these samples were determined in the hydrologic laboratory of the United States Geological Survey by V. C. Fishel. A firmly cemented, unweathered sample of the Homewood sandstone member of the Pottsville formation, obtained from the Roaring Run quarry, near Curwensville, Clearfield County, had a porosity of only 11.5 percent and a coefficient of permeability of only 4. A loosely cemented, partly leached sample of the Ridgeley sandstone of the Oriskany group obtained from the Mapleton quarry, near Mapleton, Huntingdon County (shown in pl. 6, A), had a porosity of only 7.5 percent, and its coefficient of permeability was undeterminable owing to its loose, crumbly nature but was thought to be low. As these samples are rather typical of the sandstones that occur in the area, it is apparent that the fairly large quantities of water yielded by these rocks are derived principally from joints and fractures along bedding planes rather than from their pore spaces.

Although the cementing material greatly reduces the porosity, it makes the rock hard and brittle, so that numerous joints may develop, especially in places where the rocks have suffered strong deformation, as shown in plate 7, A. The cementing material also prevents loose sand grains from entering the wells and in this way may be indirectly responsible for producing better water-bearing conditions. Other things being equal, the number and size of openings in joints and bedding planes are generally greater in beds near the surface and tend to decrease with depth, as shown in plate 11.

Most of the wells in the area ending in sandstone, as in the other types of water-bearing materials, are used only for domestic purposes, so that their ultimate water-yielding capacity is not known and must be inferred from the records of wells used

¹⁶ The coefficient of permeability is expressed by O. E. Meinzer as the number of gallons of water a day, at 60°F., that is conducted laterally through each mile of a water-bearing bed (measured at right angles to the direction of flow), for each foot of thickness of the bed and for each foot of hydraulic gradient per mile. See Stearns, N. D., Laboratory tests on the physical properties of water-bearing materials: U. S. Geol. Survey Water-Supply Paper 596 pp. 131-134, 144-152, 1928.

for industrial or public supplies. Of the numerous wells in the area that are thought to derive most or all of their supply from sandstone, 24 wells were reported to yield from 50 to 100 gallons a minute; 24 wells from 100 to 200 gallons; 9 wells from 200 to 300 gallons; 4 wells from 300 to 400 gallons; and 2 wells more than 500 gallons a minute—well 849, in Somerset County, reported to yield 570 gallons a minute; and well 31, in Clearfield County, reported to have yielded 832 gallons a minute with a drawdown of 25 feet. In addition, there are numerous wells ending in sandstone that yield from 10 to 50 gallons a minute.

A few wells in sandstone were reported to have maximum yields of less than 1 gallon a minute. Some of these wells may not have been drilled sufficiently deep to intersect an adequate number of joints; others probably encountered sandstone that has few or only tightly closed joints. Wells of this type, however, are the exception rather than the rule.

Several sandstone springs yield from 40 to 750 gallons a minute, and spring 964, in Bedford County, yields 1,800 gallons a minute from the Ridgeley sandstone. Most of these are seepage or fracture springs of the fourth magnitude or lower, as defined on page 61, but springs 566 in Huntingdon County, and 964 in Bedford County are tubular springs of the third magnitude.

WATER IN SHALE

Many wells in central and south-central Pennsylvania obtain small supplies of water from shale, which is locally often called "slate." Thin beds of shale are present in practically all the Paleozoic formations, even the sandstones and limestones, but the following formations or groups consist largely of shale or contain thick beds of shale: Waynesboro, Reedsville, Martinsburg, Juniata, Clinton, Cayuga, Onondaga, Marcellus, Hamilton, Portage, Chemung, Catskill, Mauch Chunk, Allegheny, Cone-maugh, and Monongahela. Some of the wells reported in the county well tables as obtaining water from shale or "slate" may in reality derive most of their supply from sandstones, and some of the wells in the Cayuga group reported to obtain water from limestone probably derive their supply from calcareous shale. In some other wells the nature of the water-bearing material is not definitely known.

Although shale generally has considerable porosity, the pore spaces are so small that most of the water is retained in the rock and does not become available to wells. In most places, however, the shale is more or less broken by joints and bedding planes along which water may move. In soft shales the joints generally



A. Open joints and bedding planes in a hard, firmly cemented sandstone near the surface. These openings would be excellent conduits for ground water. Upper part of Mahoning sandstone member exposed in road cut about a quarter of a mile south of Burnside, Clearfield County.



B. More or less tightly closed joints and bedding planes in a hard, firmly cemented sandstone at considerable depth. These openings are less suited as conduits of ground water than those in A. Pocono formation exposed in road cut in the Susquehanna River gorge half a mile west of Renovo, Clinton County.



A. Exposure of slightly overturned Reedsville shale, showing decrease in number and character of openings below the weathered zone. Note false dip produced in the weathered shale at the top by the soil creep from left to right. Along east foot of Standing Stone Mountain on road from Bellville to Greenwood Furnace, Mifflin County.



B. Arch Spring, issuing from a natural arch in the Lowville limestone at Arch Spring, Blair County (no. 476). The arch resulted from the enlargement of a sink hole and the collapse of part of the cave.

are tightly closed, because the material is incompetent under the heavy load of overlying material. In hard, brittle shales, particularly those in the plateau province referred to by the drillers as "slates," joints are more numerous and tend to produce openings that may be comparable to those produced in sandstones. Except in some of the "slates" of the Pennsylvanian formations, most of the joint openings in the shales appear to be restricted to the first 100 or 200 feet below the weathered zone, and many largely disappear at depths of 300 to 400 feet. This condition is shown on a small scale in plate 12, A.

In most places the shales supply enough water for domestic purposes, from 1 to 10 or 15 gallons a minute, but in some places less than one gallon a minute is obtained. From 40 to 50 gallons a minute appears to be about the maximum yield obtainable from wells in the Ridge and Valley province that are definitely known to obtain water only from shale. Most of the shale wells described in the county well tables that yield more than this amount may derive part of their supply from associated beds of sandstone or limestone, or from sandy or calcareous shale. Well 174, in Centre County, is 616 feet deep and obtained only 45 gallons a minute from the Reedsville shale, with a draw-down of about 100 feet. Well 259, in Union County, is 606 feet deep and yields only 42 gallons a minute from shale (Clinton) with moderate draw-down, and can be pumped nearly dry at 60 gallons a minute or more. Well 567, in Huntingdon County, is 756 feet deep and is reported to yield about 80 gallons a minute from shale (Hamilton or Portage), with a draw-down of 35 feet. Well 623, in Huntingdon County, is 465 feet deep and yields only 35 gallons a minute from the Marcellus shale. These wells were drilled 200 to 500 feet deeper than the average wells, in the hope of obtaining large supplies, but little or no additional water was obtained at great depths below the weathered zone. However, some wells of moderate depth supply 20 to 40 gallons a minute from shale—enough for some industrial purposes.

In the plateau province a few wells that yield 100 gallons a minute or more are reported to obtain their supplies from "slates," although here again sandy shale or thin sandstones may contribute to the supply. Typical wells of this class are wells 29 and 30, in Clearfield County, and wells 390 and 447 in Cambria County.

Most springs in shale are seepage or fracture springs of the fifth magnitude or lower and yield only a few gallons a minute, but spring 884, in Somerset County, of the fourth magnitude, is

reported to yield as much as 175 gallons a minute in wet seasons from "slate."

WATER IN LIMESTONE AND DOLOMITE

Limestone, or calcium carbonate (CaCO_3) and dolomite, or calcium and magnesium carbonate ($\text{CaCO}_3 \cdot \text{MgCO}_3$), have similar water-bearing properties and are both known as limestone to the drillers and other people in the area.

In central and south-central Pennsylvania the Cambrian and Ordovician limestones and dolomites constitute practically a single lithologic unit whose average thickness is about 6,600 feet, but if the maximum thickness of each formation were represented at any one locality, the aggregate thickness would be about 8,600 feet. In the central part of the area this unit includes the Pleasant Hill, Warrior, Stonehenge, Axemann, Carlisle, Lowville, Rodman, and Trenton limestones, the dolomites of the Gatesburg formation, and the Mines, Larke, Nittany, and Bellefonte dolomites. Exposures of some of these rocks are shown in plates 6, B and 12, B. In Fulton County the Beekmantown, Stones River, and Chambersburg limestones and the limestones in the lower part of the Martinsburg shale are included.

A much thinner aggregation of Silurian and Devonian limestones includes the Tonoloway, Helderberg, and Tully limestones and the limestones of the Clinton, McKenzie, Wills Creek, Shriver, and Onondaga formations.

The Carboniferous formations include only a few thin limestones—the Loyahanna limestone and the thin limestones of the Mauch Chunk shale and the Allegheny formation.

Origin and character of openings.—The limestone and dolomites in central and south-central Pennsylvania are generally very dense and do not appear to contain visible primary openings other than minute openings in bedding planes. The principal openings are secondary and consist of numerous joints and a few faults that originated during the severe folding of the strata. Such openings permit the descent and lateral movement of water derived from the rain and snow. In percolating downward through the soil this water takes into solution carbon dioxide, or carbonic acid, and perhaps also certain organic acids derived from decaying vegetation in the soil. As limestone and dolomite are soluble in these weak acid solutions, portions of the rock are removed along the joints, and these openings gradually enlarge to form intricate networks of underground channels. In addition to the removal of material by solution, some of the underground streams, laden with suspended matter, may enlarge their channels



Drainage features typical of limestone valleys, northernmost end of Nittany Valley, Lock Haven quadrangle, Clinton County, Small. Perennial streams heading in insoluble rock become interrupted and disappear into sink holes in the soluble limestone and dolomite and join the body of ground water. Most of the water reappears in springs and stream channels at lower altitudes, and part of it is recovered by wells. The small streams that head in gullies within the limestone valley are intermittent streams—that is, they flow only during and after heavy rains. Long Run is a perennial stream down to the point indicated near Rote and is an interrupted stream from this point to the large spring shown at Salona, below which it again becomes a perennial stream. In its interrupted portion water appears in the channel only during and after heavy rains, and the water flows entirely underground during dry periods.



by corrasion. As the channels are enlarged, caverns are formed, and enlarged vertical holes called sink holes connect the caverns with the surface. Sink holes of two types are recognized—solution sinks and collapse sinks. Solution sinks generally originate along a vertical joint or at the intersection of two such joints. A collapse sink forms when the roof of an underground channel collapses.

In their descent to the water table the underground streams seek lower levels and in many places leave dry channels above. Dry channels are generally formed if the water table is lowered as a result of regional uplift or of the down-cutting of the streams. Redeposition of limestone takes place in many of these dry channels or on the roofs of wet channels to form dripstone or flowstone. Some of the results of solution and redeposition are illustrated in figure 7.

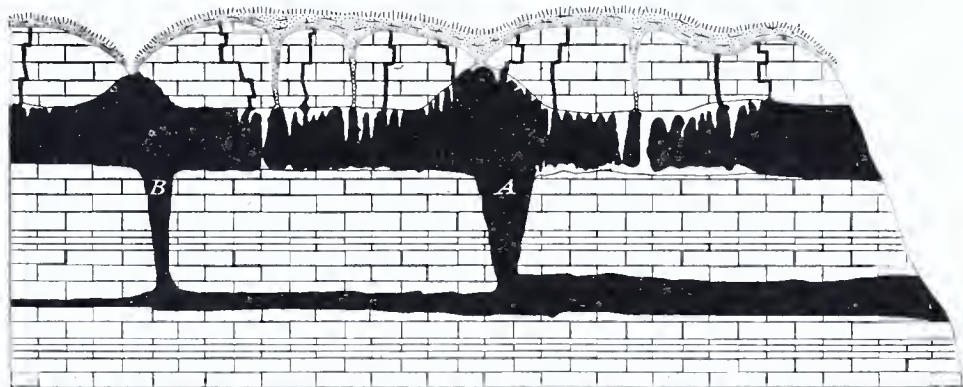


Figure 7. Diagram showing system of solution openings in limestone. A and B are vertical openings connecting the dry channel above with the wet channel below. The dry channel is connected with the surface by sink holes and contains deposits of dripstone and flowstone. (After G. C. Matson.)

By the process outlined above a system of underground drainage comparable to a surface drainage system may be developed. The underground streams, like the surface streams, become adjusted to the baselevel of the streams into which they discharge and tend to become graded to this baselevel. In the limestone valleys of this area numerous small streams disappear into sink holes, follow underground channels for distances of a few hundred feet to several miles, and reappear to form springs at or above the water table. Interrupted streams of this type are shown in plate 13. (See also pl. 14.) Interrupted streams that are graded to the water table discharge from several large caverns in this area, such as Mammoth Spring (no. 654), at the mouth of Alexander Caverns, Mifflin County; spring 143, at the discharge of Penns Cave, Centre County; and Rock Spring (no.

178) in Centre County. Arch Spring, in Blair County (no. 476) is a sluggish stream graded to the water table at the point of discharge, shown in plate 12B, but is a turbulent, corrading vadose stream where it is visible in a large sink hole 0.8 mile southwest of the spring.

In addition to the solution of limestone by water above the water table, limestone is also dissolved by ground water at the fluctuating top of the water table and for a distance below the water table, for there is generally free circulation at these levels. Ground water at considerable depth below the water table generally circulates very slowly, and as the water loses its carbonic acid it exerts much less solvent action on the rocks. Therefore it is commonly held, as by Swinnerton¹⁷ and Gardner,¹⁸ that continuous systems of solution channels or caverns do not form at considerable depths below the water table. On the contrary, Davis¹⁹ contends that limestone caverns may be formed at considerable depths below the water table.

In jointed folded limestones that contain relatively impervious confining layers of clay or shale, deep-seated artesian circulation may take place, and in this way it is possible to form solution channels at considerable depths below the water table.

In some parts of the United States and other regions limestones have been rendered cavernous by the processes described above, and by subsequent subsidence or rise of the water table the caverns thus formed have been submerged below the water table, producing ideal water-bearing conditions.²⁰ The water-filled solution channels in this area do not appear to have been formed in this way, however.

In this area most of the shallow air-filled channels occupied at times by streams appear to have been formed in the zone of aeration, but the water-filled channels encountered in wells as much as several hundred feet below the water table appear to have been formed in the zone of saturation, as suggested below, probably in part with the aid of artesian circulation.

Relation to physiography and the water table.—The periods of uplift and erosion in this area are described on pages 29-31. In plate 14 a line connecting points A and F on the ridge crests represents an eroded remnant of the Kittatinny or the Schooley peneplain, and a line passing through the top of the knolls and

¹⁷ Swinnerton, A. C., Origin of limestone caverns: Geol. Soc. America Bull., vol. 43, p. 692, 1932.

¹⁸ Gardner, J. H., Origin and development of limestone caverns: Geol. Soc. America Bull., vol. 46, pp. 1,273-1,274, 1935.

¹⁹ Davis, W. M., Origin of limestone caverns: Geol. Soc. America Bull., vol. 41, no. 3, p. 480, 1930.

²⁰ Meinzer, O. E., op. cit. (U. S. Geol. Survey Water-Supply Paper 489), p. 132.



EXPLANATION

- Drilled well
- △ Large springs



_____ is a village

Topographic map of part of Nuttall Valley, Bellefonte quadrangle, Centre County, showing location of wells and prime sites in limestone and dolomite along lines A-B, B-C, and E-F, and composite cross section, along lines A-B, C-D, and E-F, showing solution channels (indicated by circles) in limestone or dolomite encountered in drilled wells. Wells 135, 140, and E-F show springs. Approximate position of water table indicated by springs and by short horizontal lines showing wells. Outcrop of Nuttall Valley at altitude of 110 feet.² miles northeast of point A, Wells 139, 160, and 161 obtain part of their supplies from sandstones of the Fallstown formation. For detailed geologic structure see Batts, Charles, and Moore, E. C., loc. cit. and mineral resources of the Bellefonte quadrangle, Pa., U. S. Geol. Survey, Bull. 255, at section 19, line 13, p. 19.

low hills in the broad valley represents an eroded remnant of what has been called the Harrisburg peneplain. After the formation of the Harrisburg peneplain subsequent uplifts caused the streams to cut valleys into this old land surface, but there appears to be no evidence that the land has subsided appreciably since Harrisburg time, for the streams are still actively deepening their channels. The present water table (bottom pl. 14) appears to have been considerably higher in the past than it is now, but it has probably never been appreciably lower than it is now during dry seasons or droughts. Therefore, the solution channels shown seem to have been formed beneath the water table, probably with the aid of artesian circulation in the highly folded strata. The channel encountered by well 164 is more than 300 feet below the lowest water level recorded for that well. Similar conditions were found to exist in the other limestone valleys of the area.

Wells.—In the county descriptions of this report records are given of about 300 wells that end in limestone or dolomite, many of which encountered one or more solution channels. In 54 wells of this type, for which fairly reliable reports of the channels were obtained, the average depth to the principal water-bearing channel is 103 feet below the water table. They range from channels at the water table to channels 350 feet below the water table, but only 7 channels were reported at depths exceeding 200 feet below the water table, of which 5 range from 300 to 350 feet. These channels are reported to range in diameter from a few inches to several feet. Most of the channels encountered by wells appear to be only slightly inclined, but a vertical crevice about 200 feet long was reported in well 466, in Blair County, extending from a depth of about 100 feet to 300 feet. This entire crevice is below the water table.

The success of a well in limestone or dolomite depends upon the number, size, and water-bearing capacity of the solution channels encountered. As the positions of such openings can but rarely be inferred from surface conditions, there is always some uncertainty as to the success of a new well. Wells that encounter one or more water-filled channels generally yield large supplies of water, but wells that encounter no such openings yield little or no water, as illustrated in figure 8. For example, in Mifflin

County a hole was drilled 202 feet deep in limestone without obtaining any water. The driller then moved away a few feet and drilled well 648, which is 124 feet deep, and obtained an adequate supply at a depth of only 96 feet. Although some wells in this

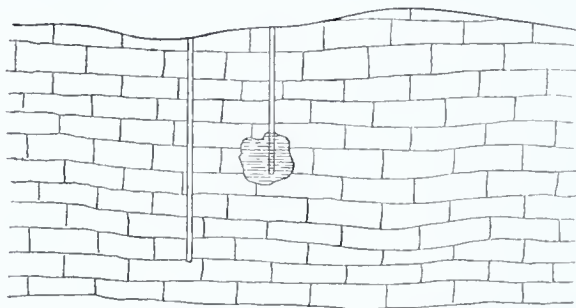


Figure 8. Diagram showing difference in conditions in wells in limestone not far apart. (After G. C. Matson.)

area yield only small supplies of water from limestone or dolomite, yet, owing to the severe folding and jointing that has affected these rocks, very few wells were reported to be absolute failures.

It is deemed unwise to drill in limestone or dolomite more than 350 feet below the local water table, as shown in nearby wells, or the local drainage level in nearby perennial streams. If a satisfactory supply is not obtainable within this depth, it would be more expedient to drill a new well a short distance away. The general strike or trend of the rocks in this area is northeast, and as solution channels are formed along joints, many of which are parallel to the bedding planes and the strike of the strata, it is generally preferable to drill the second well at a point northwest or southeast of the unsuccessful well.

Limestones and dolomites are the most productive water-bearing rocks in the area east of the Allegheny Front, which is their principal area of outcrop. Many wells used for domestic supply probably would yield several hundred gallons a minute if large pumps were used. More than 12 industrial wells are reported to yield 200 to more than 500 gallons a minute. Well 225, in Clinton County, is reported to yield 550 gallons a minute with a draw-down of only 4 feet, and therefore it has a specific capacity of 137 gallons a minute per foot of draw-down. (See p. 55.) Well 215, in Clinton County, is pumped at 50 gallons a minute but is reported to have yielded about 800 gallons a minute during a pumping test. The draw-down during this test is not known.

Clay, sand, and rock debris carried by underground streams are encountered in solution channels above the water table in

some wells and these channels should be cased off, together with all other openings above the water table, because they constitute a potential source of contamination. In some wells solution channels below the water table contain residual clays, and if such channels are pumped heavily, muddy water may result. Numerous solution channels were encountered in well 172, in Centre County (shown on pl. 14 and in log on p. 190). When the pump on this well is first started, the water discharged is muddy, and it is reported to remain muddy until after the well has been pumped about 4 hours.

Springs.—The largest springs in the area are tubular springs in limestone and dolomite. These springs are described on pages 63-64.

Caves.—In the counties east of the Allegheny Front there are many caves in limestone, and undoubtedly there are others as yet undiscovered. Excellent descriptions of 35 of these caves in the area, of which 9 are open to the public are given by Stone.²¹ Underground streams can be observed in many of these caves, and are especially prominent in Penns Cave, Centre County (spring 143); Arch Spring Cave, Blair County (spring 476, pl. 12, B) and Alexander Caverns, Mifflin County (spring 65). Penns Cave and a large part of Alexander Caverns are accessible to the public only by boat.

WATER IN COAL

Beds of coal occur in the Pottsville, Allegheny, Conemaugh, and Monongahela formations, but in this area they are most abundant in the Allegheny formation.

As coal is brittle it is readily jointed, generally along bedding planes and at right angles to these planes, similarly to shales and "slates." In many places coals are underlain by impervious underclays or shales, which help to retain the water. These features are illustrated in plate 16, B.

Coal is unimportant as a source of water in this area. Well 911, in Somerset County, is the only well in the area observed or reported to obtain water from coal. In some places coal beds can be traced by small contact springs or damp places along their outcrops, as in the vicinity of spring 90, in Clearfield County. Some of these springs doubtless issue from the coal beds, the water being held above the impervious underclays. In some springs, however, the water may issue from more permeable shale or sandstone overlying the coal. Infiltration gallery 392,

²¹ Stone, R. W., Pennsylvania caves: Pennsylvania Geol. Survey, 4th ser., Bull. G 3, 2d edition, 143 pp., 68 figs., 1932.

in Cambria County, obtains from 100 to 300 gallons a minute from an abandoned mine drainage tunnel along a coal bed, but most of the water probably comes from permeable beds above the coal.

Water from undisturbed coal beds may be potable and not highly mineralized, but water from coal beds that have been exposed to air in or near mines generally contains hydrogen sulphide, excess iron, and in some places sulphuric acid. (See p. 53.) For this reason wells that penetrate coal beds but obtain water from other rocks below the coal are generally cased down to a point below the lowest coal encountered. Where acid waters are encountered ordinary iron or steel casings are likely to be badly corroded unless they are protected in some way. It was reported that in well 431, Cambria County, the casing rusted through in 2 years as a result of contact with coal beds. In well 391, Cambria County, the 200 feet of casing is protected by an annular layer of cement 2 inches thick.

WATER IN COAL MINES

Large quantities of ground water are encountered in the numerous coal mines of the area, and must be pumped or drained from the mines. Although part of this water may occur in the coal beds, most of it probably drains downward from overlying sandstones or "slates." Some of the water thus recovered is used for washing coal, but in some places it is too acid for this purpose, as it corrodes through the water pipes. Notes obtained from interviews with mining men regarding the quantity and quality of mine water pumped in certain areas follow.

Cambria County.—According to D. Fleming, of the Ebensburg Coal Co., at Colver, the average pumpage in 1933 from workings in the Lower Kittanning coal was about 1,300,000 gallons daily. In addition, considerable water was drained out above this horizon by gravity. The area of the workings was not given.

According to Mr. Horton, of the Bethlehem Mines Co., Johnstown, the average pumpage from this company's mines near Johnstown was formerly 1,200,000 gallons daily, but in 1933 the pumps were not working and the mines were being allowed to fill. The area of the workings was not given.

Clearfield County.—According to Mr. Shobert, of the Buffalo & Susquehanna Coal & Coke Co., of Sykesville, 6,000 gallons a minute was formerly pumped from its No. 1 shaft, at Shaffer, which is 206 feet deep, and about 15,000 gallons a minute was formerly pumped from its No. 2 shaft, south of Du Bois, which is 170 feet deep. These shafts are about 5 miles apart but extend

to the same series of workings in the Lower Freeport coal. The area of workings was not given. The mine water was acid when pumped, but the pumps at the two shafts were shut down in 1924 and 1928, and the water is thought to be of better quality since the workings have filled up to the water table.

Somerset County.—According to L. M. Carter, chief engineer of the Consolidation Coal Co., Somerset, the average daily pumpage of four mines in 1933 was 1,500,000 gallons from 1,200 acres of workings in the Upper Kittanning coal at Jenners (reported to be double this amount in wet seasons); 1,500,000 gallons from 940 acres of workings in the Upper Kittanning coal at Acosta; 1,600,000 gallons from 500 acres of workings in the Upper Freeport coal at Gray; and 1,000,000 gallons from 200 acres of workings in a coal bed at Bell.

According to Andrew Diamond, of the Orenda No. 2 mine at Boswell, in 1933 an average of about 432,000 gallons a day was pumped from 800 acres of workings in the Upper Kittanning coal at a depth of 530 feet, and about 324,000 gallons a day was pumped from 400 acres of workings in the same coal at a depth of 1,000 feet.

The Bituminous Mine Drainage Survey of the Pennsylvania Department of Health has obtained some interesting information from abandoned coal mines in southwestern Pennsylvania which have been allowed to fill with water. According to H. M. Van Zandt, engineer in charge of the survey, Greensburg, water in mines that are allowed to fill generally changes from acid to neutral in a few years, and in some mines the water actually becomes alkaline. Thus when these mines fill and overflow into the streams at low points, the water is of good quality for consumers downstream, whereas the acid water discharged from active mines may render the stream waters unfit for use, especially in times of drought. According to Mr. Van Zandt, a small area underlying Beams Run, near Gray, Somerset County, was allowed to fill up to the water table, 8 feet below the ground surface. He reported that the flow of Beams Run subsequently increased and that local springs that had reduced or stopped flowing during active mining, resumed their normal flow.

WATER IN IGNEOUS ROCK

The only igneous rock in the area occurs in Perry County, where a few vertical dikes of Triassic trap rock or diabase cut through the Paleozoic sediments, as described on page .

In southeastern Pennsylvania a few wells obtain small supplies of water from diabase dikes, chiefly from the zone of disinte-

grated rock.²² The diabase is regarded as a poor water-bearer, however, and wells ending in dense, unweathered diabase would probably yield very little water. The water in diabase occurs principally if not wholly in joints.

In Perry County no wells were reported or observed in diabase. These dikes should be avoided as a source of water supply, for two reasons—(1) their hardness makes them very difficult to drill, and (2) owing to the fact that the dikes appear to have undergone less disintegration from weathering than the sediments through which they have been cut, they are probably poorer water-bearers than any of the sedimentary rocks.

RECOVERY

In central and south-central Pennsylvania ground water is recovered principally from dug wells, drilled wells, and springs. Some water is recovered from abandoned tunnels used as infiltration galleries, specially equipped mine shafts, and mine workings, as described on page 66. There may be a few driven wells in use in areas close to streams, but none were observed. No bored wells were observed in the area.

When water is withdrawn from a well there is a difference in head between the water inside the well and the water in the surrounding material at some distance from the well. The water table or pressure-indicating surface in the vicinity of a well that is discharging water has a depression somewhat in the form of an inverted cone, the apex of which is at the well, as illustrated in figure 9. In areas of flowing wells (see page 40) the cone

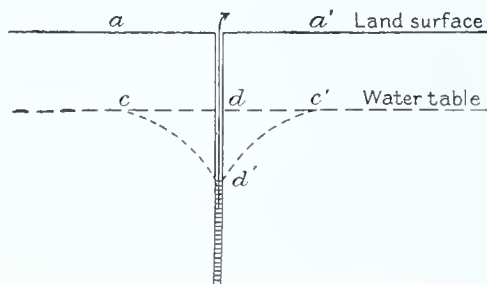


Figure 9. Diagrammatic section of a well that is being pumped, showing its draw-down (dd'), cone of influence ($cc'd'$), and area of influence (aa'). (After Meinzer.)

of influence exists only as an imaginary cone whose apex is the point of discharge of the well. In any given well the greater the pumping rate the greater will be the draw-down and the greater will be the diameter of the cone of influence and the area of in-

²² Hall, G. M., Ground water in southeastern Pennsylvania: Pennsylvania Geol. Survey, 4th ser., Bull. W 2, p 66, 1934.

fluence. If the well is heavily pumped the water levels in wells several hundred feet or even a few miles away may be lowered somewhat.

The specific capacity of a well is its rate of yield per unit of draw-down and is usually stated in gallons a minute per foot of draw-down. For example, well 224, in Clinton County, is reported to yield 550 gallons a minute with a draw-down of only about 4 feet. Its specific capacity is therefore 137 gallons a minute per foot of draw-down. Wells in some of the consolidated rocks such as shale may have yields of less than 1 gallon a minute per foot of draw-down.

When a well is pumped the water level drops rapidly at first and then more slowly, but it may continue to decline for several hours or days. Therefore, in testing the specific capacity of a well, it is important to continue pumping until the water level

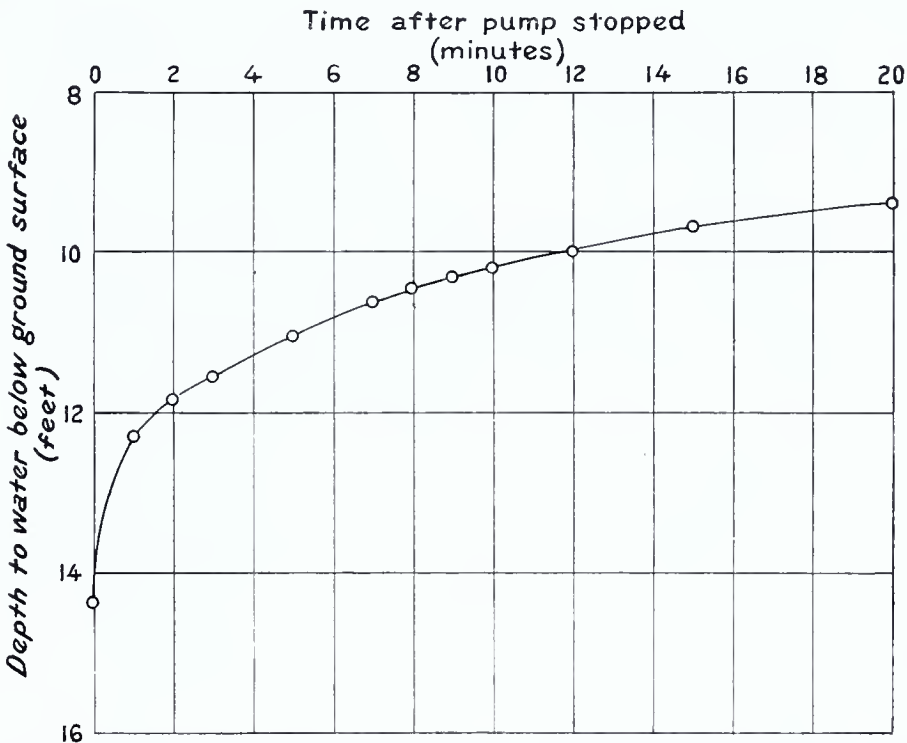


Figure 10. Recovery curve of well 602, at Mount Union, Huntingdon County. Well had been pumped at about 80 gallons a minute for 2 weeks before pump was stopped.

remains approximately stationary. When the pump is stopped the recovery is likewise rapid at first but tapers off slowly and may continue long after pumping has ceased. In the recovery curve shown in figure 10 the water level is seen to be still rising rapidly 20 minutes after the pump was stopped.

Obviously, as the cost of pumping water increases with the draw-down, a material saving can be effected by increasing the specific capacity of a well by modern methods of well construction, some of which are described below under "drilled wells."

DUG WELLS

In most of the rural regions dug wells are still commonly used for domestic and stock supplies. In general they obtain water from rather poor water-bearing material, but the large diameter of the wells provides a large infiltration area and allows ample storage of water. They are more liable to fail during dry seasons and are more subject to contamination than the deeper drilled wells. Dug wells are generally curbed with stone, brick, or wood, but some are curbed with tile or concrete. Most dug wells for domestic use are from 1½ to 3 or 4 feet in diameter, but some dug or caisson wells for industrial use are 18 or 20 feet in diameter, such as well 216, in Clinton County, which was reported to yield 1,000 gallons a minute from gravel. Some dug wells that have failed to yield adequate supplies have been deepened by drilling. Such wells are listed in the county tables of well records as dug and drilled wells.

Water is obtained from most of the dug wells by means of hand-operated lift pumps or force pumps, but in some shallow wells hand-operated pitcher pumps, chain pumps, or bucket pumps are used. The cylinders or working barrels in lift pumps and force pumps are similar and are located below the ground surface, either above or below the water surface, but a lift pump is capable only of discharging water at the pump head, whereas a force pump can force water above this point—for example, to an elevated tank. Some of the lift pumps and force pumps are equipped with pump jacks driven by gasoline engines, electric motors, or windmills. Some dug wells for industrial use are equipped with power pumps similar to those described below under drilled wells. Pitcher pumps are used on some wells where the water level is within the suction limit. Bucket pumps and chain pumps consist of crank-operated sprockets around which pass endless chains to which are attached buckets or gaskets. In bucket pumps the buckets dump the water into a reservoir in the head of the pump, whence it flows out of the discharge pipe. In chain pumps the gaskets fit into a vertical metal or wooden pipe and cause a continuous column of water to rise to the discharge pipe. Water is obtained from a few dug wells by a bucket attached to a rope, either by pulling up hand over hand or by means of a windlass.

DRIVEN WELLS

In some of the valleys containing alluvium a few driven wells are used for domestic or stock supplies. Driven wells can be used only where the materials are soft enough to permit a pipe being driven and where the material is sufficiently permeable—such as alluvium consisting of layers of gravel, sand, and silt. The driven wells generally consist of a $1\frac{1}{4}$ -or $1\frac{1}{2}$ -inch pipe with a drive-point screen at the bottom. Most of them are pumped by hand-operated pitcher pumps attached directly to the pipe. Like the dug wells, driven wells are more likely to fail during dry seasons and are more subject to contamination than the deeper drilled wells.

DRILLED WELLS

Most of the industrial ground-water supplies and a large part of the domestic and public ground-water supplies are obtained from drilled wells. All the drilled wells observed or reported in the area were drilled by percussion, chiefly by the portable cable-tool (or solid-tool) method. Wells drilled for domestic use are generally about 6 inches in diameter (casing $5\frac{3}{8}$ inches inside diameter). Those drilled for industrial or municipal use are generally 8, 10, or 12 inches in diameter, although a few are larger.

Wells in consolidated rocks.—Most of the drilled wells in this area obtain water from the consolidated rock formations and are cased through the overlying weathered rock or alluvium and several feet into the bedrock. The water may enter the well along its entire uncased portion wherever the rock is water-bearing. Wells finished in this way are called open-end wells, because the water enters only at the lower end of the casing. In some places where it may be desirable to case off water of poor quality in coal beds (p. 52) or to case off dry or clay-filled solution channels in limestone (p. 51), the casing is carried down through part of the bedrock until more favorable conditions are found. A well of this kind may require one or more reductions in the diameter of the hole as drilling proceeds, and several casings of different diameter. The yields of drilled wells in the different consolidated deposits are discussed on pages 42-50, and the complete records of all wells visited are tabulated in the county chapters.

Wells in unconsolidated deposits.—All the observed drilled wells in the area that obtain water from unconsolidated material (sand or gravel) are cased to the bottom and receive water only through the open end of the casing, like the wells described above.

The intake area and consequently the efficiency of wells drilled in unconsolidated material may be increased in several ways, none of which appear to be in use in this area. The simplest way to increase the intake area is by perforating those portions of the casing that are in the water-bearing beds or, by using screens. In drilling such a well samples of material should be taken every few feet, and the depth and thickness of water-bearing beds carefully recorded, in order to know where to perforate the casing and in order to select the proper size for the perforations. Well screens (or strainers) are manufactured in many different types and sizes, and the grain size of the water-bearing material determines the size of openings to be used in the screen. If the water-bearing material is of fine grain the perforated casing or well screen may be surrounded by an annular layer of carefully selected gravel. (See fig. 11.) By thus increasing the actual diameter and intake area of the well with a layer of gravel, the velocity of the incoming water may be reduced sufficiently to prevent the finer material from entering the well. Large supplies of water could probably be obtained from the unconsolidated materials described on page 121 if such methods of well construction were employed.

Methods of lift and types of pumps.—Drilled wells for domestic or stock use are generally equipped with hand lift or force pumps as described above, or with small power-driven pumps or wind-mills. Small pneumatic systems are used in many wells, in which the water is forced against air pressure into an air-tight tank, from which it flows under pressure to any part of the house.

Many types of power-driven pumps or lifting devices are in use on the industrial and municipal wells of the area. Most of the older installations consist of single- or double-action force pumps installed in the well or suction pumps at the surface, driven by electricity, steam, or internal-combustion engines. Some wells are pumped by air lift. In this method compressed air is forced through a nozzle submerged some distance below the water level, and the resulting mixture of water and air, being of less density, is carried to the surface, where it is discharged. In some wells where considerable draw-down is experienced, or where the water level is at considerable depth, air lifts of two or three stages are used, in which two or three air pipes of different lengths are used alternately, so that the one in use will always be sufficiently submerged.

Many of the newer installations consist of electrically driven centrifugal or turbine pumps. Centrifugal pumps are mounted

at the ground surface or in pits and can be used only where the depth to water plus the draw-down does not exceed the working suction limit. In wells with greater depth to water or greater draw-down, deep-well turbine pumps are probably the most efficient. A series of connected turbines called bowls or stages (the number of such units depending on the height the water must be forced) are submerged below the water level (or just above in some wells) and are connected by a vertical shaft to a vertical motor or pulley at the top.

Some wells in the area flow at the surface and therefore do not have to be pumped unless larger supplies are needed. (See pp. 40-41.)

Unusual types of drilled wells.—There are several wells of novel construction in this area. Well 50 and several nearby wells in Clearfield County are drilled into abandoned drifts in clay mines. Water in the drifts, which are used as infiltration galleries, is collected in reservoirs beneath the wells, whence it is pumped to the surface. Thus this method of recovery is a combination of a drilled well and an infiltration gallery. The most unusual type of drilled well encountered in the area is the inverted well (no. 460) of the Berwind-White Coal Co. near Salix, Cambria County. A small supply of cold, noncorrosive water was needed to cool the head of an air compressor in a coal-mine drift 632 feet below the land surface, and the inverted well shown in figure 11 was constructed. Water is withdrawn by gravity from the bottom of this well, where it is under a pressure of about 257 pounds to the square inch. The well supplies 20 gallons a minute continuously (all that is needed), and there is no operating cost.

SPRINGS ²³

In central and south-central Pennsylvania many of the domestic supplies, a few of the industrial supplies, and most of the municipal ground-water supplies are obtained from springs. Small springs are numerous in most of the counties, and large springs are abundant in the limestone valleys of the Ridge and Valley province.

Most of the springs in this area are gravity springs whose water does not issue under artesian pressure but which are due to an outcrop of the water table. The water from these springs percolates from permeable material or flows from large openings in rock formations, under the action of gravity, somewhat like a surface stream flows down its channel. There may be a few

²³ For further details see Meinzer, O. E., Outline of ground-water hydrology. U. S. Geol. Survey Water-Supply Paper 494, pp. 50-55, 1923.

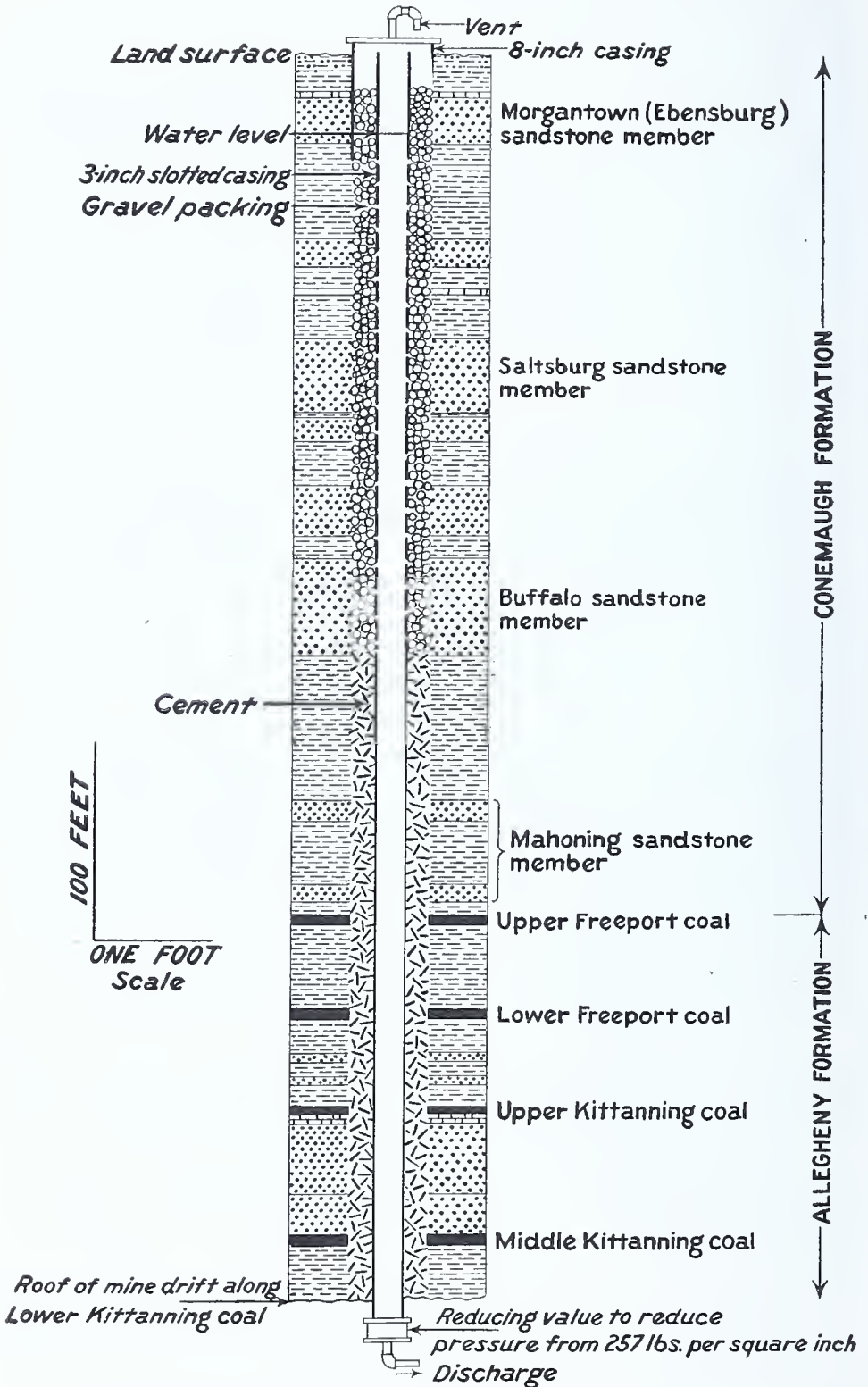


Figure 11. Diagrammatic section of inverted well of Berwind-White Coal Co. (no. 460) near Salix, Cambria County. Water enters the well through a gravel-packed slotted casing, principally from the Buffalo sandstone member. Corrosive waters associated with coal beds are cemented off. Discharge at bottom in mine drift used to cool air compressor—about 20 gallons a minute used. Geology after Phalen, W. C., U. S. Geol. Survey, Geol. Atlas, Johnstown folio (no. 174), fig. 6, 1910.

artesian springs in the area, such as no. 44, Clearfield County, and possibly no. 566, Huntingdon County.

The gravity springs may be further classified as seepage springs, in which the water percolates from numerous small openings in permeable material; fracture springs, in which the water flows from joints or other fractures in the rocks; or tubular springs, in which the water flows freely from large channels in soluble rocks. The distinctions between these types of springs are somewhat arbitrary, and all may grade into one another.

With respect to the quantity of water discharged, Meinzer²⁴ has devised the following classification of springs for convenient use in the United States:

Classification of springs with respect to discharge

Magnitude	Discharge	Magnitude	Discharge
First	100 second-feet or more	Fifth	10 to 100 gallons a minute
Second	10 to 100 second-feet	Sixth	1 to 10 gallons a minute
Third	1 to 10 second-feet	Seventh	1 pint to 1 gallon a minute
Fourth	100 gallons a minute to 1 second-foot (448.8 gallons a minute)	Eighth	Less than 1 pint a minute (less than 180 gallons or about 5 barrels a day)

Central and south-central Pennsylvania has no springs of the first magnitude, but there are many springs of the second magnitude and lower, the largest of which are tubular springs in limestone or dolomite, whose yields are summarized on page 63.

Seepage springs

Most of the springs in the area are seepage springs of the fifth magnitude or lower. Many of these are contact springs, in which the water flows to the surface from permeable material over the outcrop of impermeable or less permeable material that prevents the downward percolation of the ground water and thus deflects it to the surface. Contact springs are common on the hillsides of the plateau province, where nearly horizontal beds of clay, shale, or coal form the barriers that bring the overlying water in sandstone or slate to the surface. Spring 90, in Clearfield County, and springs 878 and 879, in Somerset County, are typical contact springs. Some of the large fracture or tubular springs that issue from the calcareous Ridgeley sandstone (springs 566 and 591, in Huntingdon County, and 964, in Bedford County) issue above shale contacts and therefore may also be regarded as contact springs. There are numerous contact springs along the outcrops of sandstone beds of the Conemaugh and Allegheny

²⁴ Idem, p. 53.



A. Roaring Spring (no. 529) at Roaring Spring, Blair County. Reported to yield about 5,500 gallons a minute.



B. Small joints in coal that might yield small supplies of water. Outcrop of Upper Freeport coal along highway in Conemaugh Township, Somerset County.

spring 566, in Huntingdon County (about 750 gallons a minute), and spring 964, in Bedford County (1,800 gallons a minute). The waters from most of the springs examined had temperatures approximating the mean annual temperature of the air (see pp. 15 and 68), but the water from spring 566 in Huntingdon County had a temperature of 64°F. in the summer of 1933, and the spring is known as Warm Spring. Possibly the water sinks to considerable depth and then emerges in a warmed condition in an artesian circulation system.

Tubular springs

The largest springs in central and south-central Pennsylvania issue from tubular solution channels in limestone or dolomite and are valuable assets to the large, fertile limestone valleys of the Ridge and Valley province. The early settlers of these valleys chose tracts that contained one or more of these springs, and two of the larger towns—Bellefonte, Centre County, and Roaring Spring, Blair County—are named after large springs in those towns.

The group includes at least 7 springs of the second magnitude, 18 of the third magnitude, 12 of the fourth magnitude, and many of the fifth magnitude or lower, besides a great many springs of different magnitudes for which no records are given in this report. Bellefonte Spring (no. 119), at Bellefonte, Centre County, with a reported discharge of 31 second-feet, or about 14,000 gallons a minute, is the largest spring in the area and is believed to be the second largest in the State.²⁶ (See pl. 15, A.) Descriptions and yields of these large springs are given principally in the tabulated records in the descriptions of Bedford, Blair, Centre, Clinton, and Mifflin Counties, but some are also described in the chapters on other counties in the Ridge and Valley province. Big Spring, at Tyrone; Axemann Spring, near Bellefonte; and Rock Spring, near Spring Mills, are reported to be of the second magnitude but were not visited by the writer. The origin of the tubular solution channels is discussed on pages 46-48.

Some tubular springs issue directly into surface streams, to which they are adjusted, such as Mammoth Spring (no. 654), in Mifflin County. Some issue from channels that have been exposed by the down-cutting of surface streams and are situated above drainage level on hillsides, such as Roaring Spring (no. 529), in Blair County. (See pl. 16, A.) Others are portions of

²⁶ Meinzer, O. E., Large springs in the United States: U. S. Geol. Survey Water-Supply Paper 557, pp. 15-16, 1927.

underground streams that have been exposed by the collapse or solution of the roofs above their channels, such as spring 144, in Centre County, which issues from the top of a deep sink hole. The entrance to Penns Cave, in Centre County, is a spring of this type, but the final discharge of the water takes place at spring 143, which is above the level of Penns Creek.

The tubular openings of most of these springs are concealed, and the water issues from the bottoms of large pools, such as Bellefonte Spring and spring 115, Centre County, (See pl. 15, A, B.) Some, however, issue from large caves in which the orifices are entirely visible, such as Arch Spring (no. 476), in Blair County. (See pl. 12, B.)

The large tubular springs that issue above drainage level are especially valuable, because their waters may be impounded to furnish water under pressure to some lower point or to furnish power. Many of the springs have been impounded to run grist-mills, small generating plants, or to drive water pumps, such as springs 133, 144, and 165 in Centre County, 241 in Clinton County, and 529 in Blair County. Hydraulic rams are used on many springs of this type to force water uphill to farm houses. Springs 550 and 552, in Huntingdon County, are so equipped. Part of the discharge of spring 506, in Blair County, is used to run a small overshot water wheel that drives a 2-cylinder force pump, forcing water to a farmhouse at the top of a nearby hill. (See pl. 17.)

In common with other types of springs in the area, most tubular springs have a variable discharge, which depends upon the amount of precipitation. Some are reported to have a nearly uniform discharge throughout the year; others are reported to yield from 2 to 10 times as much during wet seasons as during dry seasons. The variable discharge of Thompson Spring (no. 165), in Centre County, is discussed on page 40 and shown in plate 10 and figure 5.

Ebbing and flowing springs

Ebbing and flowing or periodic springs are those that have relatively greater discharge at more or less regular and frequent intervals. According to Meinzer,²⁷ "Periodic springs resemble geysers somewhat in their rhythmic action but are due to an entirely different cause. All or nearly all occur in regions underlain by limestone, and their rhythmic action has been supposed to be due to natural siphons in the rock. Periodic springs may be perennial or intermittent." Unpublished data concerning numer-

²⁷ Meinzer, O. E., op. cit. (U. S. Geol. Survey Water-Supply Paper 494), p. 54.

ous springs of this type in different limestone areas of the United States are in the files of the United States Geological Survey. The springs vary considerably in their periods of both ebb and flow and in the amount of their discharge.

The only ebbing and flowing spring reported or observed in central and south-central Pennsylvania is Flowing Spring (no. 509), at Flowing Spring station, near the village of Canoe Creek, Blair County. When visited on August 28, 1933, this spring had a measured discharge of 50 gallons a minute during the ebb period. After about an hour the discharge increased gradually to at least 200 gallons a minute (estimated) and continued at this rate for 1 hour and 15 minutes, after which the former rate of 50 gallons a minute was resumed. Thus the flow period on this date was 1 hour and 15 minutes. The ebb period was reported by local residents to be about 3 hours, but the ebb period was not checked by the writer. The temperature of the water was 50°F. during both ebb and flow, and the water was clear during both periods. A sample of the water was taken during the flow period, and the analysis is given on page 151.

INFILTRATION GALLERIES

An infiltration gallery or infiltration tunnel is an artificial tunnel which extends into the zone of saturation and through which water flows by gravity to the surface. In this area no such tunnels are known to have been constructed solely for the purpose of obtaining ground water, but several abandoned ore tunnels or mine-drainage tunnels have been utilized successfully as infiltration galleries.

An abandoned drainage tunnel (no. 392), driven along the Upper Freeport coal furnishes the entire water supply for the borough of Hastings, Cambria County. The tunnel is reported to be 2 or 3 miles long and drains mine workings under a large hill between Patton and Hastings. It slopes toward Hastings and discharges from 100 gallons a minute in dry seasons to as much as 300 gallons a minute in wet seasons. The water is not treated, although it is very hard, as shown by the analysis on page 168. A description of the supply and distributing system is given on page 157.

An abandoned sand tunnel (no. 671) in the Ridgeley sandstone of the Oriskany group furnishes the entire supply for the town of McVeytown, Mifflin County. The maximum yield is only about 30 gallons a minute, which, however, is adequate at the present time. The water is of good quality. (See analysis on p. 258, also p. 253.)

An abandoned iron-ore tunnel furnishes part of the supply for the towns of Orbisonia and Rockhill, in Huntingdon County. No data were obtainable regarding its yield.

Doubtless there are other abandoned tunnels in the area that might profitably be used as sources of water supply.

MINE SHAFTS

Although the water in the workings of coal mines in the Allegheny formation is generally of undesirable quality—at least while mining is being done (see p. 53)—many of the mine shafts penetrate several hundred feet of the overlying Conemaugh formation, which contains good water-bearing beds. In many of these shafts either the good water-bearing beds are sealed, or their waters are allowed to seep down and join the body of mine water. Some shafts, however, are equipped at different depths with water rings—devices that catch and retain the water that falls from above, so that it may be pumped to the surface and utilized.

The town of St. Michael, Cambria County, receives its entire water supply from a mine shaft thus equipped (no. 454). The shaft is 907 feet deep and is equipped with three water rings at depths of 112, 198, and 260 feet. (See log, p. 170.) Most of the water is reported to come from the two lower rings. About 325 gallons a minute is pumped from this shaft, but the maximum yield is reported to be about 1,800 gallons a minute. The water is reported to be of good quality.

A shallower shaft (no. 410) supplies the town of Revloc, Cambria County, with about 25 gallons a minute, most of which comes from a ring at a depth of 90 feet, the remainder from one at 150 feet (see pp. 158, 162).

UTILIZATION

RELATION TO TOPOGRAPHY

As the cultural development of the area is restricted largely to the valleys, it follows that the principal development and utilization of ground-water supplies also are restricted largely to the valleys, although some supplies are developed on ridges or hill-sides, and some so developed are piped for utilization in the valleys below.

In the Appalachian Plateaus province, where the strata are only gently folded, the valleys have been cut down through hard and soft beds alike, so that the particular water-bearing formations that may be encountered beneath a given valley depend upon the depth to which the stream has cut. As there are many

different valleys cut to many different depths in this province, water-bearing beds in practically all the geologic formations are utilized extensively in different valleys.

In the Ridge and Valley province, however, where the strata are severely folded, the principal valleys are cut in the more easily eroded rocks, such as shale and limestone, and the ridges are the upturned edges of hard, resistant sandstones and quartzite, so that the development and utilization of ground-water supplies are largely in the valley-forming rocks—that is, shale and limestone. Thus, in this province a limited number of geologic formations furnish most of the ground-water supplies, and the remainder, which form ridges, are not accessible to widespread exploitation.

The uses of ground water in this area are many. In the tabulated data in the county chapters of this report, the uses of ground water are divided principally into domestic, livestock, industrial, railroad, and public supplies. In addition some supplies are further classified as to their use for irrigation, generation of power, fish hatching, cooling or condensing, fire protection, bottling, or medical baths. The major uses are described below.

DOMESTIC AND RELATED SUPPLIES

Practically all the domestic supplies in rural areas and in towns or villages that have no public water works are obtained from dug wells, drilled wells, or springs. At first springs and dug wells were used, but in later years drilled wells became more popular. At the present time most of the good springs are in use. Dug wells have gradually fallen into disfavor, because they are subject to pollution and are likely to fail in dry weather. Some dug wells that have failed have either been deepened by drilling or abandoned altogether and replaced by drilled wells. Practically all new wells put down in the area are drilled.

The domestic uses of water generally include drinking, cooking, washing, and, in modern houses, the disposal of sewage. Water from some wells or springs may be dangerously polluted, and care should be taken to avoid such water or remove the source of the pollution. In this area the ground water is generally of satisfactory chemical character for all domestic purposes, but some of it contains objectionable constituents, such as iron or hydrogen sulphide, and some is so hard as to be unsatisfactory for washing. In the limestone valleys, where the water is hard, cisterns are used extensively to supply soft water for washing. A few farms are supplied entirely by cisterns, and the large barn

roofs are generally utilized as catchment areas in addition to the house roofs.

A few private homes and nurseries use water from drilled wells for irrigating plants, but very little irrigating of any kind is practiced in this area, as the rainfall is generally adequate for most crops. A few private and commercial swimming pools are filled with water from drilled wells. Many farms having springs use ground water to cool milk and other dairy products.

LIVESTOCK SUPPLIES

On many farms that are favorably situated, small streams or springs furnish adequate supplies for livestock. On other farms dug or drilled wells at the barn or house are used.

INDUSTRIAL SUPPLIES

In these counties ground water is used by many industries for many different purposes. For some industrial purposes water must be of a certain chemical character, for some it must be clear, and for others its temperature is the most important factor.

The principal industrial use of ground water in this area is for cooling. Nearly all the ice or refrigerating plants, breweries, and dairies in the area use ground water for cooling, chiefly from drilled wells but in part from springs. Several electric-light plants also use ground water for cooling. Some ground water from wells is used for air-conditioning theaters, and it is likely that many more wells will be drilled for this purpose. The great advantage of ground water for cooling is not only its relatively low temperature but its uniform temperature throughout the year, which approximates very closely the mean annual temperature of the air. The average temperature of the water in 123 representative wells and springs in all parts of the area was found to be 52.8°F. The temperature of the water in six wells and springs was only 48° or 49°F., and that of two springs was 60° and 64°F., but most of the waters ranged in temperature from 50° to 54°F. Moreover, the temperature of the water in any one well or spring probably does not vary more than 2° or 3° during the year. In contrast, the temperature of surface water may range during the year from less than 40° to more than 80°. In general the chemical character of water used for cooling is unimportant, but the water in a few wells used for this purpose, such as well 447, in Cambria County, contains so much iron as to clog the condenser pipes at frequent intervals. (See discussion of iron removal on pp. 72, 73.)

Several fish hatcheries in the limestone valleys of Bedford, Centre, and Clinton Counties utilize large volumes of clear, cold

water from springs in limestone or calcareous sandstone for growing trout.

Considerable ground water is used in this area for boilers. Water for this purpose should be relatively free from foaming and scale-forming constituents, as described on pages 74 and 76. In much of the area the ground water is of suitable chemical character for boiler use, but in some places the water requires treatment for reduction of hardness, and in some areas the ground water is probably too hard to be economically softened for boiler use.

Laundries require large volumes of clear, soft, iron-free water. Most of the laundries are in large towns or cities and use municipal water. Ground water in some parts of the area is suited to this purpose, but in most places it would be necessary to treat the water for reduction of hardness and in some places for removal of iron.

Large quantities of ground water are used in this area for the manufacture of paper and pulp. According to Mr. Heil, chief engineer of the West Virginia Pulp & Paper Co.'s plant at Tyrone, the essential requirement of water for the paper industry is that it must be clear. Thus any clear iron-free water appears to be satisfactory, regardless of other mineral constituents. Limestone springs yielding large quantities of hard, clear water supply paper mills at Roaring Spring, Williamsburg, and in part at Tyrone. The water for the large paper mill at Lock Haven is supplied entirely from Bald Eagle Creek. Mr. Heil states that most of the paper mills in the area were built 50 or 60 years ago and were situated primarily with respect to plentiful supplies of wood, so that some of the mills do not have an adequate water supply at the present time. Thus the Tyrone plant, which requires 20 million gallons of water daily and sometimes runs short, has three separate sources—Bald Eagle Creek, Hundred Springs (no. 546, Huntingdon County), and several drilled wells (nos. 464 to 467, Blair County).

There are many other industrial users of ground water in the area, including brick plants, tanneries, meat-packing plants, swimming pools, iron and steel mills, and others. The use of mine water for washing coal is discussed on page 52.

RAILROAD SUPPLIES

Railroads use water principally for drinking and for locomotive boilers. Probably most of the water used for drinking on trains in the area is obtained from the public water supplies of the larger towns and cities. The requirements of water for loco-

tive boilers are those discussed above for industrial boiler use.

The Pennsylvania Railroad and most of the other railroads in the area use surface water almost exclusively for their locomotive boilers. The New York Central, however, has several drilled wells in Clearfield County that supply locomotives satisfactorily, but some of these wells have been abandoned in favor of more suitable surface supplies.

PUBLIC SUPPLIES

The public water supplies for all the cities and some of the boroughs and smaller places in the area are obtained from surface streams, but records were obtained of more than 80 boroughs and villages that use ground water, of which about three-fourths are supplied wholly by ground water and about one-fourth by ground and surface water combined. Of those using ground water exclusively more than half are supplied by springs, and the remainder by drilled wells, springs and drilled wells, infiltration galleries, and mine shafts.

In addition there are large institutions that utilize as much ground water as some of the larger towns, including sanitariums, prisons, hotels, orphanages, asylums, and county homes for old people.

Most of the ground-water supplies are used without treatment, but some are chlorinated, and in a few drilled-well supplies in the Appalachian Plateaus province the water is treated for removal of iron and reduction of hardness.

Many of the small towns and villages that have no public water systems could readily develop safe and reliable public supplies from wells or springs that would safeguard the health of their inhabitants, especially in times of drought.

Information on the public and some of the institutional ground-water supplies is given in the county descriptions of this report.

QUALITY OF WATER

The chemical character of the ground waters and a few of the surface waters of central and south-central Pennsylvania is shown by the analytical data tabulated in the county descriptions of this report. Analyses are given of 92 samples of ground water collected in 1933, 1934, and 1936 by the writer from representative wells, springs, and infiltration galleries, distributed as uniformly as practicable within the area and among the different geologic formations. For the purpose of comparison analyses are also given of 5 samples of surface water collected in 1934 and 1936 from Centre, Clearfield and Union Counties. These analyses were made in the water-resources laboratory of the United States

Geological Survey, chiefly by E. W. Lohr but in part by Margaret D. Foster and W. L. Lamar.

Because of lack of adequate funds only partial analyses were made of most of the samples, but complete analyses were made of a few of the samples collected from the northern part of the area in 1934.

All the analyses were made after the methods outlined by Collins.²⁸ In addition, the fluoride content of several samples collected from Centre and Clearfield Counties was determined by the method worked out by Miss Foster.²⁹

CHEMICAL CONSTITUENTS IN RELATION TO USE³⁰

Total dissolved solids.—The residue from complete evaporation of a natural water consists mainly of the rock substances listed below, with which may be included a small quantity of organic material and a little water of crystallization. Waters with less than 500 parts per million³¹ of dissolved solids are generally entirely satisfactory for domestic use, except for the difficulties resulting from their hardness or occasional excessive iron content. Waters with more than 1,000 parts per million are likely to contain enough of certain constituents to produce a noticeable taste or to make the water unsuitable in some other respects. However, some waters that contain more than 1,000 parts per million are satisfactory for domestic use and for certain industrial uses, such as cooling.

The ground waters from most springs and wells of shallow or moderate depth in these counties range in concentration from 14 to about 500 parts per million and are satisfactory for all ordinary uses if not polluted by organic materials. Samples collected from 5 wells and springs, however, had concentrations of more than 1,000 parts per million, and one of them had 2,565 parts per million (spring 992, Bedford County). In contrast, four of the five samples of surface water had concentrations of only 16 to 23 parts per million.

Ground water that percolates slowly through permeable rocks is likely to be relatively constant in mineral concentration throughout the year, but ground water that flows through solution channels in limestone or dolomite may show seasonal varia-

²⁸ Collins, W. D., Notes on practical water analyses: U. S. Geol. Survey Water-Supply Paper, 596, pp. 235-261, 1928.

²⁹ Foster, M. D., Colorimetric determination of fluoride in water using ferric chloride: Ind. and Eng. Chemistry, Anal. ed., vol. 5, pp. 234-236, 1933.

³⁰ Adapted from Collins, W. D., and Howard, C. S., Chemical character of waters of Florida: U. S. Geol. Survey Water-Supply Paper 596, pp. 181-186, 1928.

³¹ One grain per U. S. gallon equals 17.118 parts per million.

tions in concentration that are comparable to seasonal fluctuations in the discharge of the channels.

Silica.—Silica (SiO_2) is dissolved from practically all rocks. The silica in a water may be deposited with other scale-forming constituents in steam boilers, but otherwise it has no effect on the use of water for most purposes.

In the 14 samples from this area for which silica was determined, the silica content is only 5 to 13 parts per million.

Iron.—Iron (Fe) is dissolved from many rock materials, particularly from pyrite and other iron-bearing minerals. The quantity of iron in ground water may differ materially from place to place, even in waters from the same geologic formation. Thus three samples of water from nearby wells in a single geologic formation (wells 82, 85 and 87, Clearfield County) have iron contents of 0.4 to 28 parts per million.

If a water contains much more than 0.1 part per million of iron, the excess may separate out after exposure to the air and settle as the reddish sediment common in many well and some spring waters. The iron imparts a disagreeable taste, and stains cooking utensils and porcelain or enamel bathroom fixtures. Iron must be removed before water can be used by laundries or for making ice. The excess iron may be removed from most waters, by simple aeration and filtration, but a few require the addition of lime or some other substance, as described below.

In this area 22 of the 91 samples of ground water contained 0.1 part per million or more of iron.³² Most of these 22 samples contained from 0.1 to 7 parts per million of iron, but 3 samples contained 26 to 28 parts per million. Although the 22 samples containing excess iron came from 10 of the 14 counties, the most common occurrence of iron-bearing waters is in the Pottsville formation of the plateau province. (See fig. 2.) Iron-bearing waters are locally called "sulphur waters" in many parts of the area, but iron and not sulphur imparts the disagreeable taste and color. However, in some iron-bearing waters that also contain hydrogen sulphide (H_2S) an excess of iron may settle out as the black ferrous sulphide (FeS). Such waters are locally called black sulphur waters.

The Coalport Borough Water Co. obtains hard, iron-bearing waters from its two wells in the Pottsville formation (wells 87 and 88, Clearfield County). Analysis 87a on page 205 shows that the raw water contains 28 parts per million of iron. Analysis

³² The amount of iron is not given in the partial analyses unless 0.1 part per million or more was present, but the amount of iron is given in all the complete analyses.

87b of a sample collected immediately after aeration shows the same iron content, but this sample began to turn cloudy soon after collection, and the iron had completely precipitated within 20 minutes, whereas for the sample of raw water several hours was required. Thus aeration greatly speeds up the oxidation of the iron. After aeration the Coalport water is treated with 40 pounds of soda ash, 50 pounds of lime, and $2\frac{1}{2}$ pounds of alum for every 36,000 gallons, and then filtered. Analysis 87c of the aerated, treated, and filtered water shows that the water has been softened and all excess iron removed. Similar methods for iron removal could be used advantageously on many ground-water supplies in the plateau province.

Calcium.—Calcium (Ca) is taken into solution as the bicarbonate by the reaction of natural waters containing carbonic or organic acids with calcium carbonate, which is the principal constituent of limestone and an important constituent of dolomite. It is also dissolved in large quantities from gypsum (calcium sulphate).

Calcium is the most abundant metallic element in nearly all the ground waters here considered and is the main cause of the hardness of these waters. Most of the ground waters contain from 30 to 90 parts per million of calcium, a few contain as little as 2 parts per million, and a few contain more than 200 parts per million. The highest concentrations of calcium in the ground waters are 480 and 558 parts per million. (See analyses 694, Mifflin County, and 992, Bedford County.)

Magnesium.—Magnesium (Mg) is dissolved from practically all rocks but mainly from dolomite and dolomitic limestones, by reactions similar to those for calcium. In most natural waters magnesium is much less abundant than calcium, but the sample from well 283, Union County, contains slightly more magnesium than calcium.

In the 45 samples for which magnesium was determined its concentration ranges from 2.5 to 146 parts per million, but in most of the samples it does not exceed 70 parts per million.

Magnesium is the only element besides calcium that causes any appreciable amount of hardness in most natural waters.

Sodium and potassium.—Sodium (Na) and potassium (K) are dissolved from practically all rocks, but they are present only in small quantities in most of the ground waters of these counties, and potassium is less abundant than sodium in all the samples for which these two elements were determined separately.

The concentration of these two elements ranges from less than 1 to 60 parts per million but is generally less than 30 parts per million in waters from most of the springs and from wells of shallow or moderate depth. Samples from well 447, in Cambria County, and from well 514, in Blair County, however, contained 125 and 453 parts per million respectively and probably represent modified connate waters—that is, sea water that became entrapped in the old marine sediments and subsequently was greatly diluted by ground water. Waters of this type are essentially solutions of common salt (sodium chloride).

Brackish or salty water has been reported in at least 10 moderately deep to deep wells in the area, including wells 7 and 10, Clearfield County; wells 201 and 212, and at depths of 736 and 815 feet in an abandoned test well for gas near Hyner,³³ Clinton County; wells 405 and 447, Cambria County; well 514, Blair County; at a depth of 742 feet in a test well for gas (no. 872), Somerset County; and at a depth of 4,000 feet in an abandoned test well for oil (no. 1057), Bedford County. Inasmuch as none of these wells are now in use, except nos. 447 and 514, for which analyses are given, the salt content of their waters is not known, but the waters from deep wells, such as no. 1057, may be highly concentrated brines such as those in deep wells in southwestern Pennsylvania, described by Piper.³⁴ All but two of these wells are in the plateau province, and these two are adjacent to this province. Wells drilled to depths of 500 feet or more below drainage level in the plateau province are likely to encounter brackish or salty water, particularly if they are drilled within any of the synclinal basins in which there is very little deep-seated circulation of ground water.

Moderate quantities of sodium have little effect on the suitability of water for ordinary use, but if the quantity is much more than 100 parts per million, it may cause foaming in steam boilers unless special precautions are taken. Some natural waters contain so large quantities of sodium salts that they are injurious to vegetation. Except for a few salty waters in deep wells described above, none of the ground waters of this area would injure vegetation, and very few of them would foam in steam boilers.

Carbonate and bicarbonate.—Carbonate (CO_3) and bicarbonate (HCO_3) in natural waters result from solution of carbonate rocks

³³ Fuller, M. L., Hyner gas pool, Clinton County, Pa.: U. S. Geol. Survey Bull. 225, p. 394, 1904.

³⁴ Piper, A. M., Ground water in southwestern Pennsylvania: Pennsylvania Geol. Survey, 4th ser., Bull. W 1, pp. 88-91, 1933.

(such as limestone, dolomite, and calcareous shale) through the action of carbonic acid in the waters. Carbonate is not generally present in appreciable quantities in natural waters but is found in some treated waters. (See analysis 87c, Clearfield County.) Most of the formations in these counties contain carbonate rocks and many of the ground waters are therefore rather high in bicarbonate, ranging in concentration from 0 to 433 parts per million. In most of the waters, however, the concentration is from 10 to 250 parts per million. The bicarbonate as such has little effect on the use of a water.

Sulphate.—Sulphate (SO_4) in ground waters is derived principally from gypsum (calcium sulphate) associated with limestone, from the oxidation of pyrite (FeS_2) and other sulphides, or from connate waters. In the ground waters of this area the sulphates derived from the latter two sources are generally of low concentration, but some of the calcium sulphate waters are of relatively high concentration. In the moderately concentrated waters sulphate is generally less abundant than bicarbonate and ranges from 2 to about 100 parts per million. Two calcium sulphate waters, however, have sulphate concentrations of more than 1,400 parts per million, the maximum being 1,764 parts per million. (See analyses 694, Mifflin County, and 992, Bedford County.)

Sulphate itself has little effect on the general use of a water. Magnesium sulphate and sodium sulphate, if present in sufficient quantity, impart a bitter taste, as in the water of Magnesia Spring (no. 992), Bedford County. Sulphate in a hard water may increase the cost of softening and forms a hard scale in steam boilers that is difficult to remove. Many of the calcium sulphate waters in this area are too hard to be softened economically.

Chloride.—Chloride (Cl) is an abundant constituent of sea water and is dissolved in small quantities from rock materials or in some localities comes from sewage. However, the sources of chloride are many, and therefore its presence in large quantities cannot be taken as a definite indication of pollution. In most of the moderately concentrated ground waters of this area the chloride content ranges from 0.2 to about 70 parts per million, but in some it is more than 100, and in one well the water contains 1,250 parts per million. (See analysis 514, Blair County.) In some of the brackish or salty waters reported in deep wells of the plateau province the chloride concentration may be very high. (See discussion of sodium and potassium, above.)

Chloride has little effect on the suitability of water for ordinary use, unless there is enough to impart a salty taste. Waters high in chloride, such as that of well 514, may be corrosive if used in steam boilers.

Fluoride.—Fluoride (F) is dissolved from certain fluoride-bearing minerals in rocks. Drinking water that contains 0.9 part per million or more of fluoride, as it does in some parts of southwestern United States, is known to produce mottled enamel during the critical period of the formation of the second teeth.³⁵

Of the 9 samples of ground and surface waters from Centre and Clearfield Counties that were examined for fluoride, only 2 contained 0.2 part per million, 2 contained 0.1 part per million, and 5 contained none. Therefore, none of the samples contained sufficient fluoride to produce mottled enamel on teeth.

Nitrate.—Nitrate (NO_3) in water is generally considered a final oxidation product of nitrogenous organic material. Therefore its presence in considerable quantity in ground water suggests the presence of harmful bacteria derived from privies, cesspools, barnyards, cultivated fields, or other places where oxidized nitrogenous matter is common.

More than half of the samples of water from these counties contain less than 1 part per million of nitrate, and some of them show none whatsoever. The nitrate content of the remainder averages about 6 parts per million, but several contain more than 20 parts, and a sample from a dug well in a field contains 66 parts per million. (See analysis 89, Clearfield County.)

Hardness.—Hardness of a water is commonly recognized by the excessive quantity of soap needed with the water in washing and by the curdy precipitate that forms before a permanent lather is obtained. The figures for hardness in the tables of analyses are generally calculated from the determined quantities of calcium and magnesium, which cause practically all the hardness of ordinary waters. The constituents that cause hardness are also the active agents in the formation of the greater part of all scale formed in steam boilers and in other vessels in which water is heated or evaporated.

Water with a hardness of less than 50 parts per million is generally rated as soft, and its treatment for the removal of hardness is rarely justified. Hardness between 50 and 150 parts per million does not seriously interfere with the use of water for most purposes, but it slightly increases the consumption of soap,

³⁵ Smith, H. V., Determination of fluorine in drinking water: Ind. and Eng. Chemistry, Anal. ed., vol. 7, p. 4, 1935.

and its removal by a softening process is profitable for laundries or other industries that use soap in large quantities. Treatment for the prevention of scale is necessary for the successful operation of steam boilers using water in the upper part of this range of hardness. Hardness of more than 150 parts per million is noticed by anyone, and where the hardness is 200 or 300 parts per million it is common practice to soften water for household use or to install cisterns to collect soft rain water. Where public supplies are softened an attempt is generally made to reduce the hardness to about 100 parts per million. The additional improvement from further softening of a whole public supply is not deemed worth the additional cost.

In the area here considered 4 samples of surface water and 17 samples of ground water have a hardness of 50 parts per million or less, the surface waters containing as little as 6 parts and the ground waters as little as 8 parts per million. The hardness of 35 samples of ground water ranges from 50 to 150 parts per million, that of 24 samples ranges from 150 to 300 parts, and that of 16 samples, three of which have a hardness of more than 1,000 parts per million, ranges from 300 to 1,994 parts. (See analyses 514, Blair County; 694, Mifflin County; and 992, Bedford County.)

Two processes for softening water are in general use, the lime and soda process and the exchange-silicate or so-called "zeolite" process, which has been developed in recent years. The Coalport Borough Water Co., which furnishes the only ground-water public supply in the area that is known to be softened, uses the lime and soda process, which also effectively removes the excess iron, as described on pages 72, 73. (See analyses 87a, b, and c, Clearfield County.) Some of the private ground-water supplies are softened and relieved of excess iron by the exchange-silicate process, in which the active agent is the "zeolite," an insoluble hydrous sodium-aluminum silicate which has the property of exchanging its sodium with the calcium, magnesium, iron, and manganese of the hard water. When all its exchangeable sodium has been replaced the silicate becomes inactive, but it can be readily reactivated by treatment with a solution of common salt (sodium chloride). The principal advantages of this method are that the water can be completely softened if desired and that close technical control is not essential, as it is in the lime and soda process.

Hydrogen sulphide.—Hydrogen sulphide (H_2S) was not detected in any of the samples of ground water from these counties when they were received in the laboratory, and therefore this constitu-

ent (present in some of the waters) is not shown in the table of analyses. Hydrogen sulphide is a gas which gives the characteristic odor to sulphur waters. It is formed during the decomposition of eggs and other organic materials that contain considerable sulphur. Hydrogen sulphide in ground waters is commonly believed to be formed by the reduction of sulphates.

Hydrogen sulphide in small quantities has been detected or reported in some of the ground waters, particularly those from dark or black shales in the Reedsville, Marcellus, Hamilton, Portage, Chemung, Pottsville, and Allegheny units of rocks. It usually disappears quickly when the water is allowed to stand in an open vessel. Treatment for the removal of iron will insure the removal of hydrogen sulphide from most of these waters. The water from White Sulphur Spring (no. 1053), Bedford County, contains hydrogen sulphide, and part of the sulphur separates as a white precipitate on the bottom and sides of the pool. In some waters containing both iron and hydrogen sulphides, a black precipitate of ferrous sulphide may form, but these so-called "black sulphur waters" were not observed in this area. Aside from imparting a slight odor and taste to water, hydrogen sulphide is entirely harmless in small quantities.

Color.—Ground waters are generally colorless, but surface waters are likely to be noticeably colored, even when quite free from suspended matter. Color in such water is derived from organic matter. The water that issues from a few of the large limestone springs has a slight bluish opalescent color, but in most of these springs the water is generally very clear.

Suspended matter.—The ground waters of this area are generally free from suspended matter, except some of the waters that contain an excess of iron. Some of the wells and springs in limestone discharge turbid water containing suspended clay and silt, generally only after heavy rains, but the water in well 172, Centre County, is reported to be turbid until after the well has been pumped several hours.

SANITARY CONSIDERATIONS

The analyses of water given in the county descriptions show only the amounts of dissolved mineral matter in the water and do not indicate the sanitary quality of the water.

Properly constructed drilled wells are generally less subject to contamination than dug wells and springs, but great care should be exercised to protect every well and spring used for domestic or public supply from pollution by organic material. Wells should

be so located as not to receive seepage from the vicinity of buildings, barns, privies, or cesspools, and should be properly sealed at the top to keep out all surface water. In the limestone valleys water in solution channels may be polluted over large areas. Some of the public water supplies from wells or springs in the area and most of the surface water supplies are chlorinated.

RELATION TO STRATIGRAPHY

The general character of the ground water in the different geologic formations or groups of formations in these counties is shown by the accompanying table of minimum and maximum quantities of iron, total solids, and hardness, which is based on 92 representative analyses. The exact stratigraphic horizon of the water-bearing beds of some wells is in doubt, as noted in the "remarks" column. This table shows the minimum and maximum of each constituent without reference to any other constituent. All the minima are not necessarily derived from the same analyses; neither are all the maxima derived from a single analysis.

On the basis of the analyses in the next table, the softest and least concentrated ground waters are those from the Oswego, Juniata, and Clinton formations, and the hardest and most concentrated waters are those from the Cayuga group. The waters from the Cambrian and Ordovician limestones are in general noticeably softer and less concentrated than those from the Silurian or Devonian limestones (Cayuga and Helderberg). The samples of water from the Pottsville formation contain more iron in objectionable amounts than those from other formations or groups. Additional notes on the quality of the waters from individual formations are given in the pages that follow.

Minimum and maximum quantities of iron, total solids, and hardness in ground waters from geologic formations in central and south-central Pennsylvania

Geologic formations or groups of formations	Number of analyses	Iron (Fe)	Total dissolved solids	Total hardness as CaCO ₃	Remarks
Pleistocene gravel (analyses 202, 232) Minimum..... Maximum.....	2	0.31 5.8	113 227	74 74	Both samples contain excess iron.
Conemaugh formation (analyses 12, 84, 89, 93, 420, 423, 429, 455, 888, 899, 924) Minimum..... Maximum.....	11	a 1.3	68 641	39 508	Most samples contain 100 to 225 parts per million of dissolved solids. Three samples contain more than 0.1 part per million of iron.
Allegheny formation: Samples containing less than 1,000 parts per million of dissolved solids (analyses 90, 389, 398, 862, 878, 884) Minimum..... Maximum..... Sample containing more than 1,000 parts per million of dissolved solids (analysis 392).....	6	a .11	19 440	14 304	Most samples contain more than 100 parts per million of dissolved solids. Only one sample contains as much as 0.1 part per million of iron.
Pottsville formation (analyses 82, 85, 87, 854, 871, 902) Minimum..... Maximum.....	6	a 28	140 566	87 306	Most samples contain 140 to 269 parts per million of dissolved solids. Two-thirds of samples contain excess iron.
Mauch Chunk shale (analyses 447, 632, 843, 940, 1141) Minimum..... Maximum.....	5	a 26	87 669	76 266	Only one sample (no. 447, Cambria County) contains more than 178 parts per million of dissolved solids and as much as 0.1 part per million of iron, and this water may be from the Pottsville.
Pocono formation (analyses 197, 521, 1056, 1135) Minimum..... Maximum.....	4	a 14	21 160	16 64	Only one sample (no. 197, Clinton County) contains as much as 0.1 part per million of iron.
Chenung and Catskill formations (analyses 522, 564, 824, 840, 1145) Minimum..... Maximum.....	5	a .22	57 252	38 168	Only two samples contain 0.1 part per million or more of iron.
Onondaga, Marcellus, Hamilton and Portage units (analyses 345, 374, 383, 489, 573, 610, 708, 740, 1133, 1156) Minimum..... Maximum.....	10	a 16	74 640	62 464	Only one sample (no. 573, Huntingdon County) contains more than 232 parts per million of dissolved solids. Three samples contain 0.1 part per million or more of iron.
Ridgeley sandstone (Oriskany group) (analyses 493, 591, 671, 815, 964) Minimum..... Maximum.....	5	a .86	32 218	16 174	Only two samples contain more than 80 parts per million of dissolved solids, and these may be in part from limestone. Only one sample (no. 671, Mifflin County) contains excess iron.

Cayuga group and Helderberg limestone: Samples containing less than 1,000 parts per million of dissolved solids (analyses 190, 215, 272, 311, 314, 358, 468, 509, 589, 593, 721, 722, 733, 801, 945, 1099) Minimum..... Maximum.....	16	.01 .37	158 907	141 732	Eight samples contain more than 300 parts per million of dissolved solids; 12 contain more than 200 parts of hardness. Only one sample (no. 721, Juniata County) contains 0.1 part per million or more of iron. Calcium sulphate waters. One sample (no. 694, Mifflin County) contains excess iron.
	3	a .87	1,098 2,565	881 1,994	
	6	.01 a	14 151	8 150	Four samples contain less than 25 parts per million of dissolved solids and less than 17 parts of hardness. None contain as much as 0.1 part per million of iron.
Oswego, Juniata, and Clinton formations: Samples containing less than 1,000 parts per million of dissolved solids (analyses 186, 253, 275, 283, 333, 719) Minimum..... Maximum..... Sample containing more than 1,000 parts per million of dissolved solids (analysis 514, Clinton formation)	1	a	2,303	1,058	Sodium chloride water.
	2	a .43	151 152	116 123	One sample contains excess iron.
	9	.01 a	59 312	51 273	Only three samples contain more than 250 parts per million of dissolved solids or more than 200 parts hardness. None contain as much as 0.1 part per million of iron.
Cambrian and Ordovician limestones and dolomites (analyses 119, 163, 164, 172, 502, 529, 664, 1005, 1111) Minimum..... Maximum.....	<p>^a Less than 0.1 part per million. Analyses by numbers (inclusive) and counties: 12-93, Clearfield; 119-190, Centre; 197-253, Clinton; 272-311, Union; 333-383, Snyder; 389-455, Cambria; 468-529, Blair; 534-639, Huntingdon; 649-708, Mifflin; 719-740, Juniata; 801-843, Perry; 854-924, Somerset; 940-1056, Bedford; 1099-1156, Fulton.</p>				

a Less than 0.1 part per million.

Analyses by numbers (inclusive) and counties: 119-190, Centre; 197-253, Clinton; 272-311, Union; 355-383, Snyder; 384-452, Cambria; 468-524, Blair; 564-639, Huntingdon; 640-708, Mifflin; 719-740, Juniata; 801-843, Perry; 854-924, Somerset; 940-1056, Bedford; 1099-1156, Fulton.

WATER-BEARING FORMATIONS

The areal distribution of the geologic formations described below is shown on the geologic map (pl. 1). Summary descriptions of the formations and their water-bearing properties are given in the generalized section on pages 18-22, and the history of their deposition is given on pages 23-31. Their local distribution is given in the county descriptions of this report. All the geologic data have been taken from the published and unpublished reports listed in the bibliography; therefore, the sources of very few of these data are separately acknowledged by footnotes in the following description. Most of the data concerning the formations of Cambrian, Ordovician, Silurian, and Devonian age have been taken from published and unpublished reports by Butts, supplemented where necessary by other reports and folios of the United States Geological Survey and by the county reports of the Second Geological Survey of Pennsylvania. Most of the data concerning the formations of Carboniferous age in the plateau province have been taken from the United States Geological Survey folios and Pennsylvania Geological Survey atlases and unpublished reports covering that area.

CAMBRIAN SYSTEM

LOWER CAMBRIAN SERIES

Waynesboro formation

General features.—The Waynesboro formation is the oldest formation known to be exposed at the surface in the area covered by this report and underlies the Pleasant Hill limestone. It is exposed only in a small wedge-shaped area between two faults in North Woodbury Township, Blair County, but doubtless underlies the Middle Cambrian formations at other places. The exposed part consists of 200 or 300 feet of green, purple, and dark shale, thin-bedded fine-grained greenish sandstone, quartzite, and quartzose conglomerate. It is known to be 1,000 to 1,500 feet thick at its type locality in Franklin County.

Ground-water conditions.—The Waynesboro is unimportant as a source of ground water, owing to its very small area of outcrop, and no data were obtained concerning its water-bearing character. However, its sandstones, quartzites, and conglomerates will probably yield adequate supplies for domestic use.

MIDDLE AND UPPER CAMBRIAN SERIES

Pleasant Hill and Warrior limestones, Gatesburg formation, and Mines dolomite

General features.—The limestones and dolomites of Middle and Upper Cambrian age have been differentiated and mapped in detail only in Bedford, Blair, Centre, and Huntingdon Counties, where,

from oldest to youngest, they are known as the Pleasant Hill and Warrior limestones, Gatesburg formation, and Mines dolomite. Limestones of similar age underlie Ordovician limestones in Fulton, Juniata, and Perry Counties and may crop out at the surface with Ordovician limestones in Clinton and Mifflin Counties. In Fulton County the Middle and Upper Cambrian formations that underlie the exposed Ordovician limestones are the Elbrook and Conococheague limestones.

The Pleasant Hill limestone (Middle Cambrian), which conformably overlies the Waynesboro formation, crops out in small areas at only three localities in Blair and Huntingdon Counties, near Henrietta, Ganister, and Graziers Mill. The lower 300 feet of the Pleasant Hill is composed of thin layered argillaceous, sandy, and micaceous limestone with some calcareous shale, and the upper 200 feet is composed of thick-bedded fine-grained dark-gray limestone. Its total thickness is about 500 feet.

The Warrior limestone (Upper Cambrian), conformably succeeding the Pleasant Hill limestone, is known to crop out in six small areas in Bedford, Blair, Centre, and Huntingdon Counties, the largest of which is at the type locality, near Warriorsmark, Huntingdon County. It is composed of limestone and dolomite with some beds of siliceous shale or shaly sandstone, quartzite, oolite, and in places edgewise conglomerate. The Warrior limestone is 1,250 feet thick between Williamsburg and Ganister, where it is fully exposed.

The Gatesburg formation disconformably overlies the Warrior limestone. Its known outcrops cover considerable areas in Bedford, Blair, Centre, and Huntingdon Counties and are characterized by heavy mantles of residual sand and sandstone boulders derived from beds in the formation by weathering, and by growths of scrub oak, for which reason they are known locally as "The Barrens." The Gatesburg is composed principally of thick-bedded coarsely crystalline steel-blue dolomite with some thin-bedded fine-grained dolomite. The distinguishing feature of the Gatesburg consists of its many intercalated layers of sandstone or quartzite, some of which are 10 feet thick. There are also a few beds of silicified oolite or oolitic chert. In Bedford County and southern Blair County the lower 500 feet, which is nearly all dolomite, is called the Stacy dolomite member, and in the same area a thin-bedded limestone about 100 feet thick, near the middle of the Gatesburg, is called the Ore Hill limestone member. The Gatesburg is 1,750 feet thick in southern Blair County, where it is fully exposed.

The Mines dolomite is conformable on the Gatesburg formation and has the same areal distribution. It consists chiefly of coarse-grained light- to dark-gray dolomite and is distinguished from the Gatesburg by the absence of sandstone or quartzite and by the abundance of scoriaceous chert, much of which is oolitic. Its thickness ranges from 150 to about 250 feet.

In the Bellefonte quadrangle, Centre County, where the overlying Larke dolomite is generally absent, there is a hiatus between the Mines dolomite and the Stonehenge limestone.

Ground-water conditions.—Like the overlying Ordovician limestones and dolomites, the Cambrian limestones and dolomites are in general abundantly water-bearing, and both together constitute the most productive water-bearers of that part of the area that lies in the Ridge and Valley province. The water-bearing properties of all these limestones and dolomites are discussed in some detail on pages 46-51 of this report.

No data were obtained concerning the occurrence of water in the Pleasant Hill limestone, owing to its small areal extent, but its composition suggests that it is probably a good water-bearer, in common with the others. The Warrior limestone, Gatesburg formation, and Mines dolomite yield adequate supplies for domestic use to wells that encounter solution channels, and owing to the folded and faulted attitude of the rocks, these openings appear to be in fair abundance, as relatively few dry holes have been reported. Large supplies, such as have been developed in wells 160 and 161, in the Gatesburg formation, Centre County, could doubtless be obtained in other places. As the Gatesburg generally forms ridges within the limestone valleys, some of the wells in it are more than 300 feet deep. The Gatesburg also supplies several large springs, such as no. 115, Centre County, and no. 502, Blair County.

ORDOVICIAN SYSTEM

LOWER AND MIDDLE ORDOVICIAN SERIES

Beekmantown group, Carlisle limestone, Black River group, and Trenton limestone

Subdivisions and general features.—Limestones and dolomites of Lower and Middle Ordovician age have been differentiated and mapped in detail in the central and southeastern parts of the area. In parts of Bedford, Blair, Centre, and Huntingdon Counties, the Lower Ordovician is represented by the Beekmantown group and the Carlisle limestone, and the Middle Ordovician is represented by the Black River group and the Trenton limestone. In Fulton County the Lower Ordovician is represented by the Beekmantown and Stones River limestones, and the Middle Ordovician by the

Chambersburg limestone and the lower part of the Martinsburg shale. Undifferentiated Lower and Middle Ordovician limestones also crop out in Bedford, Clinton, Huntingdon, Mifflin, Juniata, and Perry Counties, although in Juniata and Perry Counties only the upper part of the Middle Ordovician may be exposed.

In central Pennsylvania, where the Beekmantown group crops out over large valley areas, it has been divided into the Larke dolomite, Stonehenge limestone, Nittany dolomite, Axemann limestone, and Bellefonte dolomite, named from oldest to youngest. In Fulton County the equivalent Beekmantown limestone consists of about 2,300 feet of thick-bedded, rather pure limestones, with some interbedded dolomite and marble, and a few beds of oolite, limestone conglomerate, chert nodules, and quartz geodes.

Where present, in Bedford, Blair, and Huntingdon Counties, the Larke dolomite succeeds the Mines dolomite. The Larke consists mainly of thick-bedded coarsely crystalline dark-blue dolomite, which is distinguished from the Mines and Gatesburg by the general absence of both sandstone and chert. Where present it is about 250 feet thick, but locally it is absent.

The Stonehenge limestone consists chiefly of relatively pure blue limestone but contains some magnesian limestone and locally dark-bluish dolomite. In the Bellefonte quadrangle, where it is fully developed, it carries a basal fossiliferous limestone conglomerate. Edgewise conglomerate is common, and oolitic limestone occurs near the top of the formation. In some places calcareous shale occurs in the lower part of the formation. The Stonehenge ranges in thickness from a few feet near Orehill, Blair County, to 702 feet near Bellefonte, Centre County. In the Hollidaysburg and Huntingdon quadrangles, in parts of Bedford, Blair, and Huntingdon Counties, where the Stonehenge is generally absent, there is a hiatus between the Larke dolomite and the Nittany dolomite.

The Nittany dolomite, which conformably overlies the Stonehenge limestone where that formation is present, consists almost entirely of dolomite, mostly light gray or bluish-gray, fine-grained, and in layers as much as 2 feet thick. In some areas, its lower layers contain an abundance of chert, some of which is oolitic. It is readily distinguished from the Stonehenge limestone below and the Axemann limestone above, but where the Axemann is absent, the Nittany is with difficulty distinguishable from the overlying Bellefonte dolomite. The Nittany ranges in thickness from 1,000 to 1,250 feet.

The Axemann limestone is a comparatively pure thin-bedded dark bluish-gray limestone, with only a few thin layers of dolomite. Where present it crops out in a narrow band between the Nittany and Bellefonte dolomites. In general it ranges in thickness from 50 to 500 feet, but it is absent in parts of Blair and Huntingdon Counties, where a local hiatus exists between the Nittany and the Bellefonte.

The Bellefonte dolomite is nearly all dark fine-grained thin- to thick-bedded dolomite, lying between the Carlim limestone above and the Axemann limestone below. It includes a few light-gray beds, a little dove-colored limestone, and a little chert. Locally in Centre County it contains near the middle a sandstone bed that reaches 15 feet in thickness in some places but is absent in others. The Bellefonte dolomite ranges in thickness from about 1,000 feet in southern Blair County to more than 2,200 feet at Bellefonte, Centre County.

There is believed to be a hiatus between the Bellefonte dolomite and the overlying Carlim limestone, owing to the absence from this area of beds that occur at this horizon in the Mississippi Valley and central Tennessee.

The Carlim limestone (of Chazy age) overlies the Bellefonte dolomite in the central part of the area, and in Fulton County the Stones River limestone, which is equivalent to the Carlim and younger beds of Chazy age, overlies the Beekmantown limestone. The Carlim limestone, which is quarried extensively for flux, consists principally of pure dark-bluish finely crystalline limestone, with some layers of dolomite at the base and a persistent siliceous and argillaceous limestone 10 to 50 feet thick at the top, known as the Lemont argillaceous limestone member. The Carlim limestone ranges in thickness from 100 to about 400 feet. The Stones River limestone in Fulton County is also largely pure limestone but has some magnesian limestones and cherts at the middle. It is not well exposed in Fulton County but is 675 to 1,050 feet thick in the adjacent Franklin County.

There is a great hiatus between the Carlim limestone and the overlying Lowville, owing to the absence from this region of several thousand feet of beds found in Tennessee.³⁶

The Black River group is represented in the central part of the area by the Lowville and Rodman limestones, and in Fulton County by the Lowville and Chambersburg limestones. (See generalized section on page 21.)

³⁶ See Butts, Charles, and Moore, E. S., *Geology and mineral resources of the Bellefonte quadrangle, Pa.*: U. S. Geol. Survey Bull. 855, pl. 7, 1935.

The Lowville limestone, which disconformably overlies the Carlim limestone, is a dark compact very pure limestone that has a tendency to conchoidal fracture, and like the underlying Carlim it is quarried extensively for flux. (See pl. 6, B.) The Lowville ranges in thickness from a few feet to 180 feet but is absent near Lemont, Centre County, where the Lemont argillaceous limestone member of the Carlim limestone is overlain by the Rodman limestone. The Rodman limestone is a thin but persistent thin-bedded impure, very fossiliferous limestone that marks the top of the quarry rock in central Pennsylvania, as neither the Rodman nor any overlying rock is quarried. It ranges in thickness from about 20 to 30 feet.

In Fulton County the Chambersburg limestone (restricted), which overlies the Stones River limestone, consists of thin-bedded tough dark limestone, generally very fossiliferous, with irregular clayey partings. At the top are interbedded shales forming a gradation into the overlying Martinsburg shale. The Chambersburg is about 100 feet thick in Fulton County but is as much as 750 feet thick in Franklin County.

In central Pennsylvania the Trenton limestone overlies the Rodman limestone and underlies the Reedsville shale. There is a hiatus between the Rodman and Trenton limestones in this region. Here the Trenton limestone is a thin-bedded dark compact or noncrystalline, moderately argillaceous and siliceous limestone. It ranges in thickness from 350 to 630 feet from southwest to northeast. In Fulton County the Trenton horizon is represented by the lower part of the Martinsburg shale.

Ground-water conditions.—Like the underlying Cambrian limestones and dolomites, the Lower and Middle Ordovician limestones and dolomites are in general abundantly water-bearing, and both together constitute the most productive water bearers of that part of this area that lies in the Ridge and Valley province. The water-bearing properties of all these limestones and dolomites are given on pages 46-51 of this report.

These rocks generally yield adequate supplies for domestic use to wells that encounter solution channels, and, in common with those of Cambrian age, these rocks appear to have abundant openings, owing to the numerous folds and faults, as only a few dry holes have been reported. Most of the wells in these formations were put down for domestic use, but large industrial or municipal supplies have been obtained from these rocks where needed, as in well 145, 163, 164, and 172, Centre County, and well 545, Blair County.

Numerous large tubular springs issue from solution channels in these limestones and dolomites, the larger of which are described on pages 63-64. (See pl. 12,B, 15, 16,A, and 17.)

Several analyses of water from the Cambrian and Ordovician limestones and dolomites summarized on another page show that waters from these rocks are only moderately concentrated, are only moderately hard, and as a group are much softer and less concentrated than waters from the Silurian or Devonian limestones.

UPPER ORDOVICIAN SERIES

Reedsville and Martinsburg shales

General features.— Overlying the Middle Ordovician limestones is a thick shale, known in the central part of the area as the Reedsville shale and in Fulton County as the Martinsburg shale. In the county reports of the Second Geological Survey of Pennsylvania this shale has been called "No. III," "Hudson River and Utica," and "Lorraine and Utica" shale.

The Reedsville crops out at the base and on the slopes of ridges that surround numerous anticlinal valleys in the Ridge and Valley province, and the Martinsburg occupies a similar position in Fulton County. In the central part of the area the Reedsville grades upward into the overlying Oswego sandstone. In Fulton County and probably in adjacent parts of Huntingdon, Juniata, and Perry Counties the Martinsburg shale as now defined is equivalent to the Trenton limestone, Reedsville shale, and Oswego sandstone of central Pennsylvania and underlies the Juniata formation. In Fulton County the lower 800 feet of the Martinsburg is shale and the upper 1,200 feet is sandstone, the upper part of which is equivalent to the Oswego sandstone.

The Reedsville consists chiefly of brown, greenish, and black clayey to sandy shale, generally with black shale in the lower part, thin limestone beds or concretions at intervals, grading upward into gray sandstone at the top. Some of the beds contain pyrite, and some of the black shales are so highly carbonaceous or graphitic as to have been mistaken for coal. An exposure of the Reedsville shale is shown in plate 12,A. The shale mapped as the Reedsville ranges in thickness from about 900 feet near Bellefonte to about 1,200 feet near Tyrone. This shale, as measured in other parts of the area by the Second Geological Survey of Pennsylvania, ranges in thickness from about 1,000 feet in Centre County to 1,870 feet at Orbisonia, Huntingdon County, and to about 2,300 feet in Mifflin County. The Martinsburg shale in Fulton County is about 2,000 feet thick.

Ground-water conditions.—The Reedsville and Martinsburg shales generally yield small but reliable supplies of water that are adequate for domestic or stock use. Wells in this shale that are more than 200 feet deep do not appear to yield any more than the wells less than 200 feet deep. Well 174, in Centre County, was drilled 616 feet deep in the Reedsville shale in the hope of getting a large supply, but no additional water was obtained below the weathered zone. This well yielded only 45 gallons a minute, with a draw-down of about 100 feet, and 40 or 50 gallons a minute appears to be about the maximum yield obtainable from the Reedsville or the Martinsburg regardless of depth.

Two analyses of water from the Reedsville (no. 649, Mifflin County, and no. 1053, Bedford County) are summarized on page and show the waters to be moderately hard. One sample contains excess iron, probably derived from pyrite. Some of the waters, such as that of spring 1053, Bedford County, contain small quantities of hydrogen sulphide. Except for the iron in one sample, these waters would be entirely satisfactory for most purposes.

Oswego sandstone

The Oswego sandstone overlies the Reedsville shale and underlies the Juniata formation in central Pennsylvania east of the Allegheny Front, where it forms the inner and lower crest of the double-crested ridges that surround the anticlinal limestone valleys. The outer and higher ridges are formed by the Tuscarora quartzite, and the intervening space is occupied by the Juniata formation. It also crops out less conspicuously in the "Seven Mountains" at the junctions of Centre, Clinton, Union, Snyder, Mifflin, and Huntingdon Counties. The sandstone was called "Oneida conglomerate" by the Second Geological Survey of Pennsylvania and has been called "Tyrone conglomerate" and "Bald Eagle conglomerate" by some geologists. The Oswego, Juniata, and Tuscarora formations are grouped together as the "Oneida and Medina" in most of the county reports of the Second Geological Survey of Pennsylvania. In Fulton County sandstone equivalent to the Oswego is included in the upper part of the Martinsburg shale. Along the southern boundary of Perry County the sandstones equivalent to the Oswego appear to decrease in thickness toward the east and are not represented at or east of the Susquehanna Water Gap.³⁷

The Oswego sandstone generally consists of brown to gray thick-bedded fine- to coarse-grained sandstone. Locally it con-

³⁷ Stose, G. W., Unconformity at the base of the Silurian in southeastern Pennsylvania: Geol. Soc. America Bull., vol. 41, no. 4, pp. 632-633, fig. 3, 1930.

tains conglomerate with both quartz and shale pebbles and some beds of greenish, gray, or red shale or sandy shale. Some of the sandstone is arkosic, and some of it is cross-bedded. The general absence of fossils and other criteria indicate its probable terrestrial origin. The Oswego sandstone ranges in thickness from 800 to 1,000 feet in the central part of the area but is believed to be absent in parts of Perry County, as stated above.

Ground-water conditions.—The Oswego sandstone is unimportant as a source of ground water, as it crops out only on steep, forested ridges or uplands. It yields small supplies to a few wells in Centre and Clinton Counties and to a few hillside springs, such as no. 177, Centre County, and no. 253, Clinton County. In most of these wells the yield is surprisingly low for sandstone. Well 175, Centre County, is 200 feet deep and yielded only 20 gallons a minute, with a large draw-down, and well 176, nearby, is 342 feet deep and yielded only 55 gallons a minute, with a draw-down of 100 feet. Thus, at least in its outcrop area, it appears to yield no more water than the Reedsville shale. A sample of water from spring 253, Clinton County, contains only 18 parts per million of dissolved solids and has a hardness of only 8 parts per million. Thus on the basis of this one analysis the Oswego appears to yield very soft water.

Juniata formation ³⁸

General features.—The Juniata formation overlies the Oswego sandstone where that formation is present and overlies the Martinsburg shale in the southeastern part of the area. It was called the "Red Medina" or the "Lower Medina" by the Second Geological Survey of Pennsylvania. It crops out in all the counties of the Ridge and Valley province in high, narrow valleys between crests of the double-crested ridges composed of Oswego sandstone and Tuscarora quartzite, and in upland areas such as the "Seven Mountains."

The Juniata formation is composed almost wholly of red or brown shale and sandstone. The sandstones are generally fine-grained, micaceous, and in part cross-bedded; the shales are lumpy, sandy, and somewhat micaceous. The formation is non-fossiliferous throughout but contains sun cracks and ripple marks. Like the Oswego sandstone, the Juniata is thought to be of terrestrial origin. The Juniata ranges in thickness from 800 to 1,200 feet in the central part of the area but is only 300 to 450 feet

³⁸ Classified as Silurian by E. O. Ulrich, Charles Butts, G. W. Stose, and the Pennsylvania Geological Survey.

thick in Fulton County and only about 68 feet thick at the Susquehanna Water Gap.³⁹

Ground-water conditions.—Like the Oswego sandstone and the Tuscarora quartzite, the Juniata formation is unimportant as a source of ground water, owing to its topographic position. All these formations supply small hillside springs and contribute water to the small perennial streams that head in the high ridges formed by them. A few shallow domestic wells in mountainous areas obtain small supplies of water from the Juniata, but no data are available as to its maximum water-bearing capacity. Only one sample of water (analysis 186, Centre County) was collected from the Juniata, and it contained 151 parts per million of dissolved solids and had a hardness of 150, indicating a good average water.

SILURIAN SYSTEM

Tuscarora quartzite

General features.—The Tuscarora quartzite overlies the Juniata formation. Because of its highly inclined attitude and extreme hardness, it forms the summit and larger part of most of the high, even-crested ridges that characterize the Ridge and Valley province. (See pl. 3 and 4,B.) It is called the "White Medina" or "Upper Medina" in the early geologic reports. It is the source of ganister, the utilization of which is described on page 13. The Tuscarora is a white to gray, medium thick-bedded quartzose sandstone or quartzite, composed of transparent grains of quartz. It ranges in texture from fine-grained, firmly cemented quartzite to a loosely cemented conglomeratic sandstone. Locally it contains red and green argillaceous sandstone in the upper 20 to 75 feet, which Swartz ⁴⁰ has called the Castanea sandstone. It is about 270 feet thick in Fulton County, where it is called the Tuscarora sandstone, is 600 to 800 feet thick in the central part of the area, and is about 850 feet thick near Bedford.⁴¹

Ground-water conditions.—Like the underlying Juniata formation and Oswego sandstone, the Tuscarora quartzite is unimportant as a source of ground water, owing to its topographic position on the summits of the highest ridges. Its abundant talus, which is strewn over the sides of the high ridges, supplies numerous springs, such as nos. 268 and 280, in Union County. Well 838, on the crest of Blue Mountain, in Perry County, is the only well observed on the outcrops of the Tuscarora, and it is only a shallow well for domestic use. No analyses of water from the Tuscarora

³⁹ Stose, G. W., op. cit., pp. 639, 641.

⁴⁰ Swartz, F. M., Silurian sections near Mount Union, central Pennsylvania. Geol. Soc. America Bull., vol. 45, pp. 109-111, February 28, 1934.

⁴¹ Bonine, C. A., Unpublished report on the Bedford quadrangle.

were made, but as it is composed almost wholly of quartz, its water is probably very soft and similar to that from the Oswego sandstone. (See analysis 253, Clinton County.)

Clinton formation

General features.—The Clinton formation overlies the Tuscarora quartzite and crops out on the flanks of the high ridges of the Tuscarora in all the counties in the Ridge and Valley province. It is composed chiefly of gray and greenish sandstone and shale and a small proportion of limestone and greenish and red sandstone. Most of the limestone is in thin layers in the upper part of the formation. Thin layers of sandstone occur in the middle, and thick sandstones generally occur near the top and bottom. A persistent hard coarse-grained sandstone near the top, which is locally calcareous, fossiliferous, and ferruginous, is called the Keefer sandstone member. Another persistent red highly ferruginous sandstone occurs near the base. In most places the Clinton contains characteristic beds of fossiliferous or oolitic hematite (iron) ore.

Swartz,⁴² following the Maryland Geological Survey, subdivides the Clinton in central Pennsylvania into the Rose Hill shale, the Keefer sandstone, and the Rochester shale, named in ascending order. The United States Geological Survey recognizes the Rochester age of the post-Keefer beds of the Clinton but does not consider them a separate formation.

In most parts of this area the Clinton is 750 to 800 feet thick, but near Bedford⁴³ it appears to be only 640 feet thick, and at Honey Grove, Juniata County, Butts and Ulrich⁴⁴ found it to be 940 feet thick.

In most of the county reports of the Second Geological Survey of Pennsylvania the Clinton formation and most of the Cayuga group are mapped together as the "No. V" formation.

According to Butts⁴⁵ there is a hiatus between the Clinton formation and the overlying McKenzie formation, owing to the absence from this area of beds representing the Lockport dolomite, but Swartz⁴⁶ suggests the possible equivalence of the McKenzie and the Lockport and provisionally includes the McKenzie in the Niagara series. The United States Geological Survey includes the McKenzie in the Cayuga group.

⁴² Swartz, F. M., *op. cit.*, vol. 45, pp. 111-121.

⁴³ Bonine, C. A., *op. cit.*

⁴⁴ Ulrich, E. O., Maryland Geol. Survey, Silurian, pp. 353, 354, 1923.

⁴⁵ Butts, Charles, and Moore, E. S., *Geology and mineral resources of the Bellefonte quadrangle, Pa.*: U. S. Geol. Survey Bull. 855, pp. 52, 53, 1935.

⁴⁶ Swartz, F. M., *Correlation of the McKenzie shale [abstract]*: Geol. Soc. America Bull., vol. 41, no. 1, pp. 117-118, 1930; Silurian sections near Mount Union, central Pennsylvania: Geol. Soc. America Bull., vol. 45, pp. 125-126, 1934.

Ground-water conditions.—The Clinton formation supplies numerous domestic wells and a few industrial wells, several of which flow. The shales that make up the bulk of the Clinton will probably not yield much more than 50 gallons a minute, even to deep wells, as shown by the records of wells 226, Clinton County, and 259, Union County. Well 514, Blair County, which is 496 feet deep, is reported to yield about 385 gallons a minute from sandstones of the Clinton. The Clinton also supplies numerous hillside springs, many of which are used for public water supplies, such as spring 333, Snyder County, and spring 719, Juniata County.

Five samples of water from wells and springs in the Clinton were analyzed, four of which were very soft and low in dissolved mineral matter. None of the samples contain excess iron. (See analyses 275, 283, Union County; 333, Snyder County; 719, Juniata County; and p. 81.) A sample from a deep well in Blair County (no. 514), however, contains 2,303 parts per million of dissolved solids, mostly sodium chloride (common salt). This is believed to be only a local occurrence of connate water.

Cayuga group

Subdivisions and general features.—In the central and southern parts of the area the Cayuga group, which overlies the Clinton formation, has been divided into four formations—in ascending order the McKenzie formation, the Bloomsburg redbeds, the Wills Creek shale (restricted),⁴⁷ and the Tonoloway limestone. The thickness of the Cayuga group ranges from about 750 feet in southern Fulton County to 1,600 feet in the central part of the area and possibly 2,000 feet in Mifflin County and parts of Juniata County. In some reports of the Second Geological Survey of Pennsylvania the lower part of the Cayuga group was mapped with the Clinton formation as the "No. V" formation, and the Tonoloway limestone was, at least in part, included with the overlying Helderberg limestone; in other reports the entire Cayuga group and the Helderberg limestone were included in the Lewistown limestone; in still others only the Cayuga group was included in the Lewistown limestone; and in the report on Union and Snyder Counties the Bloomsburg was mapped separately, the underlying beds were included with the Clinton, the Wills Creek shale (restricted) was separately mapped as "Salina," and most if not all of the Tonoloway was included with

⁴⁷The Bloomsburg was formerly considered a basal member of the Wills Creek shale.

the Helderberg. The Cayuga group forms fertile valleys in all the counties of the area that are east of the Allegheny Front.

The oldest formation of the Cayuga group, the McKenzie formation, overlies the Clinton formation and in most places consists of greenish shale interbedded with many thin layers of limestone and near the middle some red shale. Locally limestone predominates in the lower part, and in some places it makes up nearly the whole formation. The McKenzie ranges in thickness from 110 feet ⁴⁸ in Perry County to 400 feet in the central part of the area.

The Bloomsburg redbeds, overlying the McKenzie formation, generally consists of nonfissile lumpy red shale, with lesser amounts of gray, green or yellow shale, red sandstone, and locally impure limestone, but along the Maryland boundary it consists wholly of red sandstone. In the western and southern parts of the Ridge and Valley province the Bloomsburg is only about 50 feet thick, but its thickness increases greatly toward the east, until in Perry County it is more than 500 feet thick. It is about 1,800 feet thick in eastern Pennsylvania, where it is believed to represent the entire Cayuga group.⁴⁹

The Wills Creek shale (restricted) overlies the Bloomsburg. It consists chiefly of thin fissile calcareous gray shale weathering yellow green, with thin layers of limestone near the base and at many other horizons, and in some places it contains red shales resembling those of the Bloomsburg. Crystals of gypsum (hydrous calcium sulphate) have been observed near the base and probably occur at other horizons, to judge from the quality of the ground water described below. The formation ranges in thickness from 400 to 500 feet in its western and southern outcrops to perhaps 750 feet in its central outcrops.

The Tonoloway limestone overlies the Wills Creek shale and is prevailingly a thin-bedded to laminated fine-grained impure to fairly pure dark-blue to nearly black limestone, which locally may contain calcareous shale. It is quarried in many places in preference to the overlying Helderberg limestone. It is 400 to 600 feet thick in most places, is about 820 feet thick at Mount Union,⁵⁰ is possibly only 100 to 200 feet thick in the eastern part of the area, and is absent in southeastern Perry County.

The absence of the uppermost Silurian, Lower Devonian, and lower Middle Devonian at the Susquehanna Water Gap, in south-

⁴⁸ Swartz, C. K. and F. M., Early Silurian formations of southeastern Pennsylvania: Geol. Soc. America Bull., vol. 42, no. 3, p. 626, 1931.

⁴⁹ Idem, pp. 656-660.

⁵⁰ Swartz, F. M., Silurian sections near Mount Union, central Pennsylvania: Geol. Soc. America Bull., vol. 45, p. 128, February 28, 1934.

eastern Perry County, has been held by some geologists to be due to their having been faulted out. Recently Willard⁵¹ discovered a small patch of Oriskany in fault relation to the Hamilton, so that at least one of the missing formations is now known to have been deposited.

Ground-water conditions.—The Cayuga group and the overlying Helderberg limestone are important water-bearing formations in most of the counties in the Ridge and Valley province and are probably the most productive water-bearers in Union, Snyder, Juniata, and Perry Counties.

The McKenzie, Bloomsburg, and Wills Creek formations show great variations in both their composition and their water-yielding capacity from place to place. Some wells that encounter chiefly shale yield only very small supplies, while those encountering highly calcareous shale or limestone generally yield moderately large supplies. The Bloomsburg generally yields only small supplies, but its water, at least in some places, is of better quality than that of other formations of the Cayuga. (See below.) Owing to the fact that calcareous shale and limestone respond somewhat similarly to the drill, plus the fact that the entire Cayuga group is in general poorly exposed, it is difficult in many places to determine in what part of the Cayuga group a well may end.

As the Tonoloway and Helderberg limestones have been mapped separately in only a small part of the area, and as together they constitute a single unit of limestone with similar water-bearing properties, it is difficult to determine which limestone supplies many of the wells. In some respects their water-bearing properties are similar to those of the Cambrian and Ordovician limestones, but as the Tonoloway and Helderberg are relatively thin, their solution channels appear to be less abundant than those of the older and thicker limestones. However, many of the wells encounter channels, and there are several large caverns and tubular springs in these rocks. Yields of 500 gallons a minute or more have been obtained from the Helderberg or Tonoloway, as shown by the records of wells 215 and 224, Clinton County, and several large tubular springs issue from these formations, such as no. 277, Union County, and no. 472, Blair County.

As shown by the 19 analyses summarized on page 81, the waters from the Cayuga group and Helderberg limestone are

⁵¹ Willard, Bradford, Oriskany at Susquehanna Gap, Pa.: Geol. Soc. America Bull., vol. 42, pp. 697-706, September 30, 1931.

generally harder and more highly mineralized than those from any other formations in the area. Three samples contain from 1,098 to 2,565 parts per million of dissolved solids and 881 to 1,994 parts of hardness, due chiefly to calcium sulphate derived from gypsum in the rocks. Only two samples contain iron in objectionable quantities, but most of the samples are too hard for many industrial uses, and some are unfit for practically any use except cooling. The Helderberg limestone and the Bloomsburg redbeds may yield water of better quality than the other units, and the Wills Creek shale may yield the poorest water, but the conditions mentioned above make this difficult of determination in many places.

DEVONIAN SYSTEM

LOWER DEVONIAN SERIES

Helderberg limestone⁵²

Subdivisions and general features.—The Helderberg limestone overlies the Tonoloway limestone, which was included with it in many of the earlier reports. In parts of this area and in Maryland the Helderberg has been divided into three limestone members, the Keyser at the base, the Coeymans in the middle, and the New Scotland at the top. A slight hiatus may exist between the Keyser member and the Tonoloway limestone, represented in Maryland by limestone that is absent in this area. Another hiatus exists between the New Scotland member of the Helderberg and the overlying Oriskany group, owing to the absence from this area of the Becraft limestone.

The Keyser limestone member, which forms the larger part of the Helderberg in this area, consists of a lower series of limestones, generally with many nodular layers, and an upper series of relatively shaly limestones. Locally a pure massive limestone occurs near its base, and in some places it contains chert. In thickness it ranges from about 90 to 200 feet. The Coeymans limestone member ranges in character from a coarse crinoidal limestone, sandy in its lower part, to a calcareous sandstone, and generally contains chert. It is generally only 3 to 10 feet thick. The New Scotland limestone member consists of shale and impure limestone containing white chert, generally with a thin basal limestone. It ranges in thickness from 10 to about 60 feet. The thickness of the Helderberg limestone ranges from 150 to 200 feet in the northern and central parts of the area to 280 to 350 feet in southern Fulton County.

⁵² For detailed descriptions see Reeside, J. B., Jr., *The Helderberg limestone of central Pennsylvania*: U. S. Geol. Survey Prof. Paper 108, pp. 185-225, 1917; and Swartz, F. M., *The Helderberg group from central Pennsylvania to southwestern Virginia*: *Pennsylvania Acad. Sci. Proc.*, vol. 3, pp. 75-88, 1929.

Ground-water conditions.—The ground-water conditions of the Helderberg limestone and the underlying Tonoloway limestone are described on pages 95-96.

Oriskany group

Subdivisions and general features.—In this area the Oriskany group comprises two formations—the Shriver chert and the overlying Ridgeley sandstone. In some early reports beds representing the Shriver were called the “Stormville shale” or “Oriskany shale” or were included with the underlying Helderberg limestone; and beds representing the Ridgeley were called the “Oriskany sandstone.”

The Shriver chert varies greatly in character, ranging from a thin-bedded, highly siliceous limestone or calcareous sandstone to a gray or black shale, in part calcareous. Generally there is more or less chert, locally in beds as much as 6 inches thick. The thickness of the Shriver in most of the area ranges from 40 or 50 feet to 300 feet, but it may be absent in parts of Union County; if so, a local hiatus exists there.

The overlying Ridgeley sandstone ranges in character from an impure calcareous soft brown sandstone to a pure-white fine- to coarse-grained quartzose sandstone. In most places it is highly calcareous in the unweathered condition, and upon removal of the calcareous cement by weathering it crumbles to loose sand. Locally it is conglomeratic. In general the Ridgeley is highly fossiliferous, although in many places the fossils have been leached out, leaving fossil molds or casts. This feature readily distinguishes the Ridgeley from practically all other sandstones in the area. Although relatively thin, its outcrops generally form sandy ridges rising above the shale and limestone valleys. Such ridges are especially prominent in Huntingdon and Mifflin Counties, where the Ridgeley is well developed and is quarried extensively for glass sand. The thickness of the Ridgeley ranges from 20 feet to more than 200 feet. (See p. 13 and plate 6,A.)

Ground-water conditions.—The Ridgeley sandstone is a productive water-bearer in Bedford, Blair, Huntingdon, and Mifflin Counties, but it is relatively unimportant in the other counties of the Ridge and Valley province. In the above named counties it yields adequate supplies to numerous domestic wells, and at Altoona, Blair County, it supplies from 125 to 300 gallons a minute to a few industrial wells of moderate depth. (See wells 493 and 496, Blair County.) Large supplies may be expected from the Ridgeley where it is well developed and where it lies

below drainage level. However on Warrior Ridge, in Huntingdon County, and similar ridges, where both the Ridgeley and the Shriver lie above drainage level, the leached sandstone appears to be so permeable that most of the water falling upon it drains out rapidly to form numerous large springs at the base of the hills, such as nos. 566, 570, 591, Huntingdon County, and no. 764, Bedford County. Consequently wells drilled on such ridges must be cased through considerable loose sand or sandstone, and water must be sought in the underlying limestone, as exemplified by wells 556, 588, and 589, Huntingdon County. The Shriver, which is less important than the Ridgeley, supplies a few domestic wells in the above named counties and may in part supply well 492, Blair County.

The Ridgeley generally yields water of good quality, soft, and low in dissolved mineral matter. As shown on page 80, only 2 out of 5 samples contain more than 80 parts per million of dissolved solids, and only 1 sample contains excess iron. No samples were obtained from the Shriver.

MIDDLE DEVONIAN SERIES

Onondaga formation, Marcellus shale, and Hamilton formation

General features.— Along the Maryland boundary the Onondaga formation, Marcellus shale, and Hamilton formation have been mapped together in early reports as the Romney shale, whose total thickness is 1,400 to 1,500 feet. Elsewhere the three formations have generally been distinguished and mapped separately, although in some early reports beds representing the Onondaga were included with the Marcellus. In recent detailed studies Willard⁵³ uses the name Hamilton as a group term, and includes in the Hamilton group the Marcellus formation and his Mahantango formation, the latter equivalent to the Hamilton formation as used previously and in this report. In a subsequent report⁵⁴ he also includes the underlying Onondaga as the lowest formation of his Hamilton group, and recognizes in the Onondaga in central Pennsylvania an upper noncherty limestone member overlying a lower calcareous shale member, and in eastern Pennsylvania a cherty limestone member overlying his lower Esopus shale member. These formations generally form lowlands except where resistant sandstones in the Marcellus shale and the Hamilton formation form ridges, as in Perry County.

⁵³ Willard, Bradford, Hamilton group of central Pennsylvania: Geol. Soc. America Bull., vol. 46, pp. 195-224, pl. 19, 3 figs., February 28, 1935; Hamilton group along the Allegheny Front, Pennsylvania: Idem, pp. 1275-1290, 2 figs., August 31, 1935.

⁵⁴ Willard, Bradford, The Onondaga formation in Pennsylvania: Jour. Geology, vol. 44, no. 5, pp. 578-603, July-August, 1936.

The Onondaga formation overlies the Oriskany group. In its western outcrops it is composed largely of dark-green or bluish shale, some of which is calcareous, with dark-gray argillaceous limestone at the top. It is more calcareous toward the east, where it consists of dark blue-gray to black limestone with some interbedded black shale. Its thickness generally ranges from 40 to about 145 feet except in Centre County, where it appears to be entirely absent locally, there being a slight hiatus between the Ridgeley sandstone and the Marcellus shale.

At Selinsgrove Junction, Northumberland County, about 145 feet of unfossiliferous light-gray calcareous shale lying between the Oriskany and the Onondaga limestone was correlated by Willard⁵⁵ with the Esopus shale of eastern Pennsylvania and New York and later made the lower calcareous shale member of the Onondaga formation.

The Marcellus shale normally succeeds the Onondaga formation. In the eastern and western parts of the area it is composed chiefly of black fissile carbonaceous shale, but in Perry, Juniata, and Snyder Counties interbedded sandstones break up the Marcellus into four members which Willard⁵⁶ has named, from bottom to top, the "Shamokin black shale member," the "Turkey Ridge sandstone member," the "Mexico sandstone member," and the "Mahanoy black shale member." Willard's two shale members are similar lithologically to the typical Marcellus. His Shamokin member, which locally contains large siderite concretions and thin beds of limestone, attains a maximum thickness of 250 feet at Selinsgrove Junction, and his Mahanoy member attains a maximum thickness of about 200 feet near Mexico. His Turkey Ridge sandstone member consists of coarse hard olive-gray sandstone with a maximum thickness of 200 feet in Juniata County. His Mexico sandstone member is a light-gray to white fine-grained sandstone with a maximum thickness of 275 feet in Juniata County.

The total thickness of the Marcellus ranges from about 10⁰ feet in the west to 675 feet in western Juniata County, where the sandstone members are well developed.

The overlying Hamilton formation generally consists largely of brown, yellow, olive-green, and black shales, with some interbedded sandstones, but in some places the sandstones are quite thick and predominate. Willard⁵⁷ has introduced the name

⁵⁵ Willard, Bradford, The Devonian section at Selinsgrove Junction, Pa.: *Am. Midland Naturalist*, vol. 13, no. 4, p. 228, 1932.

⁵⁶ Willard, Bradford, Hamilton group of central Pennsylvania: *Geol. Soc. America Bull.*, vol. 46, pp. 202-204, February 28, 1935.

⁵⁷ *Idem*, p. 205.

"Mahantango formation" to replace the name Hamilton formation, and in central Pennsylvania he recognizes in it three faunal facies—the Skaneateles, Ludlowville, and Moscow—and two important lithologic phases—the Montebello sandstone of Claypole⁵⁸ and a continental phase which he calls "Knobsville." The massive coarse sandstone phase is about 1,000 feet thick in southern Dauphin and Perry Counties, where it is regarded by Willard as representing practically all of Skaneateles and Ludlowville time, but it thins and ultimately disappears to the northwest, in Juniata and Snyder Counties, and to the northeast, in counties adjacent to the area. The continental phase comprises 800 to 1,000 feet of fresh-water red or green beds developed locally in northern Fulton County, and according to Willard it extends from a horizon near the base of his Hamilton into beds younger than Hamilton.

In Bedford County Willard⁵⁹ finds his Mahantango in three parts, from bottom to top, a shale exposed on Gander Run, a sandstone at Chaneyville, and a shale seen near Frame school. The sandstone at Chaneyville (182 feet thick) differs lithologically from the Montebello sandstone member of Claypole and is not correlated with it. These localities are between Warrior Ridge and Polish Mountain in Monroe and Southampton Townships.

The thickness of the Hamilton ranges from about 500 feet in western Juniata County to 1,375 feet in Bedford County.

Ground-water conditions.—The Onondaga is a rather poor water-bearer and is relatively unimportant owing to its small areal extent. It yields small supplies to a few domestic wells and may contribute somewhat to the supply of two industrial wells (nos. 574 and 576, Huntingdon County), but it probably will not yield large supplies, as in most places it consists largely of shale. A single analysis of water that may have been derived from the Onondaga indicates a good moderately hard average water (no. 374, Snyder County).

The Marcellus shale is also a rather poor water-bearer but generally yields from 1 to about 10 gallons a minute to wells of moderate depth. In common with the Reedsville shale, the Marcellus generally does not yield appreciably more water to deep wells than to shallow wells, as indicated by wells 520, Blair County, and 623, Huntingdon County. Probably 30 to 40 gallons

⁵⁸ Claypole, E. W., A preliminary report on the paleontology of Perry County, Pa.: Pennsylvania Geol. Survey, 2d ser., vol. F₂, p. 67, 1885.

⁵⁹ Willard, Bradford, Hamilton group along the Allegheny Front, Pa.: Geol. Soc. America Bull., vol. 46, p. 1279, August 31, 1935.

a minute represents the maximum yield obtainable from the Marcellus. The shales of the Hamilton formation appear to yield no more than the Marcellus shale, as shown by the record of well 219, Clinton County. Wells of moderate depth that encounter water-bearing sandstones in the Hamilton yield moderately large supplies, as shown by the records of wells 572 and 573, Huntingdon County, which yield 90 and 300 gallons a minute, respectively, with small draw-down. The maximum water-yielding capacity of these sandstones has not been exploited beyond domestic needs elsewhere in the area. On the basis of 5 analyses the waters from the Marcellus and Hamilton are generally only moderately mineralized and moderately hard, except for the sample obtained from well 573, Huntingdon County, which contains 640 parts per million of dissolved solids and has a hardness of 464 parts. Excess iron was present in 3 of the samples, and hydrogen sulphide and excess iron were reported in the waters of several other wells in each formation. Probably these constituents are derived from pyrite associated with the dark carbonaceous shales in both formations.

UPPER DEVONIAN SERIES
Tully limestone and Portage group

Subdivisions and general features.—In the reports of the Second Geological Survey of Pennsylvania the rocks between the Hamilton and the Chemung formations were classified as Genesee and Portage, and in the reports on Centre and Clinton Counties a limestone now regarded as the Tully was erroneously mapped with the Helderberg limestone. In Maryland rocks of this age were included with the Chemung in the Jennings formation. In his description of the Ebensburg quadrangle Butts⁶⁰ recognized the Genesee shale by its lithologic similarity to the Genesee of New York, and applied the name "Nunda formation" to the overlying rocks of Portage age. Later, in his description of the adjacent Hollidaysburg and Huntingdon quadrangles, Butts⁶¹ divided the Portage group into two formations, the Brallier shale above and the Harrell shale below. The bed Butts had previously mapped as Genesee was made the Burket black shale member at the base of the Harrell, because it carried no distinctive Genesee fossils, and the Genesee was regarded as absent. Willard⁶² suggests the possible equivalence of the Burket and the Genesee of New York. A foot of limestone that in places occurred beneath

⁶⁰ Butts, Charles, U. S. Geol. Survey Geol. Atlas, Ebensburg folio (no. 133), p. 2, 1905.

⁶¹ Butts, Charles, Geologic section in Blair and Huntingdon Counties, central Pennsylvania: Am. Jour. Sci., 4th ser., vol. 46, pp. 523-524, 1918.

⁶² Willard, Bradford, Portage group in Pennsylvania: Geol. Soc. America Bull., vol. 46, p. 1217, August 31, 1935.

the Burket was placed in the Hamilton, although Butts recognized from its distinctive fossils that it was probably the feather edge of the Tully limestone. The presence of the Tully limestone in Pennsylvania was later definitely established by Willard.⁶³ In a recent study of the Portage group throughout Pennsylvania Willard⁶⁴ has divided the group into two different formations called the "Fort Littleton" and the underlying "Rush." He includes in his Rush formation the Tully limestone⁶⁵ as the basal member, followed by the Burket black shale member of Butts. The Harrell shale (minus the Burket member) and the Brallier shale of Butts are the lower members of Willard's Fort Littleton formation and are followed above by three other members, named the "Losh Run shale," "Trimmers Rock sandstone," and "Parkhead sandstone." Willard's Losh Run shale appears to be a faunal facies recognized within the Brallier at some places, and his Trimmers Rock sandstone may be regarded as a sandy phase of the upper part of the Brallier in the eastern part of the area. According to Butts,⁶⁶ Willard's Parkhead member may be of Chemung age.

In this area the Tully limestone is thickest in Clinton County, where it consists of at least 185 feet of hard gray thin-bedded limestone containing dark shale partings between the beds and numerous pyrite nodules. It is only 40 feet thick in Centre County, about 1 foot thick in Blair County, and absent or only a few inches thick in the other counties. Where it is absent the Hamilton and the Portage are separated by a hiatus.

The Burket black shale member consists entirely of black fissile shale. It is 50 to 80 feet thick along the Allegheny Front, 110 feet in Perry County, but locally absent in Bedford County.

The Harrell shale (exclusive of the Burket member) consists of very soft brownish-gray or olive-green fissile shale. Its thickness, including the Burket member, ranges from 100 to about 400 feet.

The Brallier shale along the Allegheny Front consists chiefly of pale greenish-gray micaceous, sandy, and slaty shale. Beds of hard fine-grained greenish or bluish sandstone generally occur at intervals throughout the formation, especially near the top. From Huntingdon and Fulton Counties eastward the upper part

⁶³ Willard, Bradford, A Tully limestone outcrop in Pennsylvania: Pennsylvania Acad. Sci. Proc., vol. 8, pp. 57-62, 1934; *Hypothyridina venustula* (Hall) in Pennsylvania: Am. Jour. Sci., 5th ser., vol. 29, pp. 93-97, February 1935.

⁶⁴ Willard, Bradford, Portage group in Pennsylvania: Geol. Soc. America Bull., vol. 46, pp. 1195-1218, August 31, 1935.

⁶⁵ The Tully limestone is considered a separate formation by the United States Geological Survey.

⁶⁶ Personal communication.

of the Brallier shale is composed largely of this hard ridge-making sandstone—the Trimmers Rock sandstone of Willard. The Brallier ranges in thickness from about 1,200 feet in Fulton County to about 2,200 feet in Huntingdon County.

Ground-water conditions.—No wells were observed in the Tully limestone in Centre and Clinton Counties, where the formation is fairly thick, and it is thin or absent elsewhere in the area. The numerous shale partings indicate that it is probably not a good water-bearer.

Most of the wells in the Portage group are shallow domestic wells that yield from half a gallon to about 10 gallons a minute. The only wells reported to obtain water from sandstones in the Portage are likewise domestic wells with similar yields. Possibly large supplies could be obtained from it in the eastern part of the area, where it contains considerable sandstone. Two industrial wells (nos. 489 and 490, Blair County) indicate about the maximum yields obtainable from shales of the Portage. One well yields only 30 gallons a minute, with a draw-down of 110 feet; the other yields 22 gallons a minute, but the draw-down at 15 gallons a minute is 30 feet. Thus in general the Portage is rather a poor water-bearer, but it can be depended upon for domestic or small industrial supplies.

On the basis of four analyses (nos. 383, 489, 740, and 1156, p. 80) the waters of the Portage are only moderately mineralized and moderately hard, and none of the samples contain excess iron. Some of the waters contain small quantities of hydrogen sulphide. These waters appear to be somewhat softer and less mineralized than those from the underlying Onondaga, Marcellus, and Hamilton formations but are somewhat harder and more mineralized than those from the overlying Chemung and Catskill formations.

Chemung and Catskill formations

General features.—The Chemung and Catskill formations overlie the Portage group and underlie the Pocono formation. They form rolling hills in the Ridge and Valley province and form the foothills along the east slope of the Allegheny Front. The boundary between the marine Chemung formation and the continental Catskill formation is difficult to define for the area as a whole, owing to the fact that the Catskill, as now considered, is a continental phase of Devonian sedimentation that, when traced from west to east across the area, is found to extend downward gradually through the Chemung and finally into the

Portage at Selinsgrove Junction, where Willard⁶⁷ believes there is no marine Chemung. For this reason much of what has been mapped as Catskill is of Chemung age. A more complete treatment of this complex problem is given by Willard.⁶⁸

The Chemung formation consists largely of gray, drab, green, brown, and chocolate-colored shale and shaly sandstone but contains some thin beds of sandstone and conglomerate. Most of the brown or chocolate-colored shales are confined to the upper third, and the lower two-thirds contains largely gray, drab, or green beds. Layers of red shale occur near the top in the western exposures and at lower points in the eastern exposures. The formation contains abundant marine fossils throughout except in the red beds. In the Huntingdon and Hollidaysburg quadrangles Butts⁶⁹ has named some of the prominent sandstones and conglomerates—in descending order the Piney Ridge sandstone member, the Allegrippis sandstone member, and the Saxton conglomerate member. The marine Chemung is 3,500 feet thick in Huntingdon and Bedford Counties but is considered absent at Selinsgrove Junction, where the beds of Chemung age are all of the nonmarine red Catskill type.

The Catskill formation consists mainly of red to brown shale but contains also red, brown, and gray sandstone and gray and greenish shale. The shale is generally a coarse, lumpy mudrock. The sandstone is generally fine-grained, hard, and in thin beds, although a few of the sandstone beds are 20 to 50 feet thick. Some of the sandstones are cross-bedded, and many of the beds exhibit sun cracks and ripple marks. The Catskill interfingers in the west with the marine Chemung and in the east with the marine Portage, so that marine fossils are found near the base of the Catskill. The exposed Catskill ranges in thickness from 1,200 to 2,000 feet along the Allegheny Front to perhaps 5 000 feet in Perry County. There is evidence that the Catskill underlying the plateaus west of the Allegheny Front is considerably thinner toward the west and ultimately dies out in Fayette County.⁷⁰

Ground-water conditions.—Most of the drilled wells that tap the Chemung formation are domestic wells that range in depth from 12 to 210 feet and in reported yield from 1 to 5 or 10 gallons a

⁶⁷ Willard, Bradford, The Devonian section at Selinsgrove Junction, Pa.: Am. Midland Naturalist, vol. 28, no. 4, pp. 232-235, July 1932.

⁶⁸ Willard, Bradford, "Catskill" sedimentation in Pennsylvania: Geol. Soc. America Bull., vol. 44, pp. 495-516, June 30, 1933.

⁶⁹ Butts, Charles, U. S. Geol. Survey Geol. Atlas, Huntingdon-Hollidaysburg folio (no. 227) [in press].

⁷⁰ Willard, Bradford, op. cit., pp. 498-501, June 30, 1933.

minute. Of four wells that were reported to yield only about 1 gallon a minute, two end in sandstone and two end in shale. Two industrial wells in Perry County (nos. 823 and 824) are 270 and 300 feet deep and were reported to yield 80 to 85 gallons a minute from sandstones of the Chemung. A draw-down of 100 feet was reported in testing the 300-foot well at 100 gallons a minute. The domestic wells in the Catskill are similar in depth to those in the Chemung, but some of their reported yields are less. Out of about 10 wells in the Catskill reported to yield 1 gallon a minute or less, two wells ending in sandstone were reported to yield only about one-sixth of a gallon a minute. Two industrial wells in Perry County (nos. 839 and 840) are 338 and 330 feet deep and are reported to yield respectively 30 and 40 gallons a minute from shales of the Catskill. Thus in general the Chemung and Catskill formations are rather poor water-bearers, even to deep wells that encounter sandstone.

In the Ridge and Valley province the waters of the Chemung and Catskill are generally of good quality for most purposes. Five analyses indicate that the waters contain moderate quantities of dissolved minerals and are generally soft or only slightly hard (nos. 522, 564, 840, 1145, p. 80). Two of the samples analyzed contained about 0.2 part per million of iron, and the rest contained less than 0.1 part.

In the plateau province wells drilled deep enough to encounter the Catskill or Chemung are likely to encounter salt water. However, these formations are deeply buried in most parts of the plateaus. A "large" yield of salt water in the Catskill was reported at a depth of 450 feet from well 201 in northern Clinton County. Further discussion of the occurrence of salt water in this province is given on page 74.

CARBONIFEROUS SYSTEM

MISSISSIPPIAN SERIES

Pocono formation

General features and subdivisions.—The Pocono formation consists largely of hard, resistant sandstone and is one of the three principal mountain-making formations of the area. It caps the Allegheny Front, underlies the plateaus, forms two high ridges in the southeastern part of the plateau province, and forms numerous high ridges in the southern and southeastern parts of the Ridge and Valley province. It conformably overlies the Catskill formation. A view of the Pocono is shown in plate 11, B.

The Pocono includes two distinct lithologic subdivisions, and locally other subdivisions have been made. The upper main sub-

division is the Burgoon sandstone member, which consists of thick-bedded coarse yellowish-green to bluish-gray sandstone that is locally conglomeratic. The Burgoon member is 300 to 525 feet thick along the Allegheny Front. The lower main subdivision is unnamed in most parts of the area and consists of gray sandy shale, gray and red sandstone, red shale, and locally beds of clay and beds of conglomerate. At some places along and west of the Allegheny Front a bed of red shale about 40 feet thick, known as the Patton shale member, immediately underlies the Burgoon member.

In the Broad Top Basin, at the junction of Huntingdon, Bedford, and Fulton Counties, Reger ⁷¹ has subdivided the Pocono into four members, separated by intervening beds of shale or sandstone. Below the Burgoon sandstone member (50 to 240 feet thick) he recognizes the Riddlesburg shale member (marine, 75 to 95 feet thick), the Broad Ford sandstone member (30 to 100 feet thick), and at the base the Berea sandstone member (160 to 190 feet thick).

Locally thin beds or streaks of coal occur in the Pocono, but none are of commercial value.

The thickness of the Pocono ranges from 450 to 1,175 feet along the Allegheny Front to about 2,000 feet in Perry County. The Pocono has not been subdivided in Perry County.

Ground-water conditions.—The Pocono is a good water-bearer in places away from its outcrop and where it lies not far below drainage level. These conditions exist in the northern part of the plateau province along the West Branch of the Susquehanna River in Clinton County and northern Clearfield County, where several wells from 80 to 300 feet deep were reported to yield from 50 to 200 gallons a minute, and the largest yields were reported from wells less than 100 feet deep (well 34, Clearfield County, and well 212, Clinton County). However, in most parts of the plateau province, where the Pocono is deeply buried within a synclinal basin, it is likely to contain only salt water, such as was obtained in well 212, Clinton County.

In the Ridge and Valley province, along the Allegheny Front, and in the anticlinal ridges in Somerset County and southeastern Cambria County the Pocono has not been exploited much beyond the domestic needs of a few cabins and highway stands, owing to the rugged nature of its outcrops. It generally yields adequate domestic supplies, but large yields cannot be expected from these

⁷¹ Reger, D. B., Pocono stratigraphy in the Broadtop Basin of Pennsylvania: Geol. Soc. America Bull., vol. 38, no. 2, pp. 405-407, June 30, 1927.

outcrop areas, in which the water lies deep and under very low head. This is shown by the unsuccessful attempts that have been made to obtain large supplies from the Pocono in several places along the Allegheny Front, where the beds are drained for considerable depths. Well 1056, in Bedford County, is 400 feet deep and yields 35 gallons a minute, but very little water was obtained down to a depth of 385 feet. Three wells (no. 926) in Somerset County are 800 to 1,000 feet deep, and each yields only about 25 gallons a minute.

On the basis of four analyses, summarized on page 80, and numerous reports, the waters in the Pocono are generally of very good quality except, of course, where salt water may be encountered as described above. The waters are generally very soft and contain only small quantities of dissolved minerals. Only one sample contained as much as 0.1 part per million of iron (no. 197, Clinton County).

Loyalhanna limestone

General features.—The Loyalhanna limestone overlies the Burgoon sandstone member of the Pocono in the southern part of the plateau province and along the Allegheny Front as far north as northern Blair County. The Loyalhanna has been variously classed as a member of the Pocono or the Mauch Chunk or the Greenbrier limestone of Maryland, but it is now considered a separate formation equivalent to the Ste. Genevieve limestone.⁷²

The Loyalhanna ranges from a siliceous limestone to a calcareous sandstone and was called the "Siliceous" limestone in the reports of the Second Geological Survey of Pennsylvania. Some of it is largely quartz sand cemented by calcium carbonate, but other beds are composed of limestone containing a few quartz grains. It is especially distinguished by its extremely cross-bedded structure, and the cross-bedding is strikingly revealed on weathered outcrops.

Where present the Loyalhanna ranges in thickness from 27 to 52 feet, but it is entirely absent north of Blair County and east of the Allegheny Front. There is a hiatus between the Loyalhanna and the Burgoon sandstone member represented in other areas by several limestone formations, and this hiatus is further increased where the Loyalhanna is absent.

Ground-water conditions.—As the Loyalhanna is a thin formation of small areal extent, crops out only in mountainous areas,

⁷² Butts, Charles, *The Loyalhanna limestone of southwestern Pennsylvania*, especially with regard to its age and correlation: *Am. Jour. Sci.*, 4th ser., vol. 8, pp. 249-257, 1924.

and lies buried at considerable depth in other places, it is unimportant as a source of ground water, and no wells were observed that tap it.

Mauch Chunk shale

General features and subdivisions.—The Mauch Chunk shale conformably overlies the Loyalhanna limestone or disconformably overlies the Pocono formation. It crops out in two synclinal basins in eastern Perry County, in the Broad Top and other synclines in Huntingdon, Bedford, and Fulton Counties, around the Wellersburg syncline in southern Bedford and Somerset County, along the Allegheny Front, and in anticlinal ridges or deep river valleys in several parts of the plateau province. It is everywhere a valley-forming rock.

In Perry County the exposed part of the Mauch Chunk is about 1,500 feet thick and consists almost wholly of soft red shale. The lower part is calcareous in some places, but no limestone beds have been found. In the Broad Top region the Mauch Chunk is only 1,100 feet thick and is nearly all soft red shale, but it contains thin beds of greenish and red sandstone, green shale, and limestone. In the middle and at or near the bottom are beds of red and gray limestone, some of which are siliceous and resemble the Loyalhanna. The lowermost limestone, the Trough Creek limestone member, attains a maximum thickness of about 50 feet but may be absent in some places.

In southernmost Somerset County the Mauch Chunk is more than 400 feet thick and consists largely of red and green shale but contains green and red sandstones and, near the base, the Greenbrier limestone member. Farther north along the Allegheny Front the Greenbrier member is absent and the Mauch Chunk diminishes rapidly in thickness, first to 175 to 200 feet in Cambria and Blair Counties and northern Somerset County and to 30 feet in Centre County, and it is absent altogether in parts of Clearfield and Clinton Counties, although locally in Clinton County it is as much as 100 feet thick. Although it is still characterized by red shale, the Mauch Chunk along the Allegheny Front contains at the base considerable coarse greenish to gray heavy-bedded sandstone.

The gradual thinning and ultimate disappearance of the Mauch Chunk northwestward are regarded as probably due to its erosion after deposition, so that the overlying Pottsville lies disconformably on the Mauch Chunk or the Pocono. Moreover, the Pottsville in this region is late Pottsville. As much as 10,000

feet of earlier Pottsville beds deposited in regions to the south are represented by this hiatus.⁷³

Ground-water conditions. — Scanty data indicate that in the Ridge and Valley province the Mauch Chunk generally yields from 1 to 5 gallons a minute to shallow domestic wells 25 to 100 feet deep. Most of these wells are reported to obtain water from red shale, but a few wells in Huntingdon and Fulton Counties obtain water from the Trough Creek and other limestones. In this part of the area the Mauch Chunk has not been exploited beyond domestic needs except for two deep wells (nos. 632 and 633) on Broad Top Mountain, in Huntingdon County, which encountered very little water in sandstones of the Mauch Chunk.

In the northern part of the plateau province, where the Mauch Chunk is thin or absent, it is unimportant as a water-bearer. In the south-central part of the province the Mauch Chunk, though thin, contains considerable sandstone and appears to be abundantly water-bearing at a few localities where deep wells have tapped it. In well 849, in Somerset County, 340 gallons a minute was obtained from the Connoquenessing sandstone member (Pottsville) and 230 gallons a minute was obtained from underlying sandstones of the Mauch Chunk. (See log, p. 295.) Well 854, in Somerset County, tested at 400 gallons a minute, taps the Mauch Chunk, but most of the water is attributed by the owners to the overlying Pottsville. However, in a nearby well (no. 855), which taps both formations, a similar yield is attributed by the driller to the Mauch Chunk. Well 447, in Cambria County, which yields 180 gallons a minute, may end either in the Pottsville or the Mauch Chunk. The water in all these wells contains considerable iron. No data are available regarding the maximum water-yielding capacity of the Mauch Chunk in other parts of the plateaus, including southern Somerset County, where it is thicker and contains limestones. In most places it is deeply buried or its outcrops are relatively inaccessible.

On the basis of 5 analyses, summarized on page 80, the waters of the Mauch Chunk appear to be of good quality in the Ridge and Valley province but of poor quality locally in the plateau province. This may be due to the fact that the soluble minerals have been largely leached from the rocks in the outcrop areas, but still remain where the rocks are buried beneath the plateau. The Mauch Chunk waters in the plateau province are hard and contain an

⁷³ Butts, Charles, The unconformity between the Mississippian and Pennsylvanian, and its bearing on geologic correlation [abstract]: Science, new ser., vol. 27, pp. 992-993, 1908.

abundance of iron, and in this respect they are similar to the Pottsville waters.

PENNSYLVANIAN SERIES

Pottsville formation

General features and subdivisions.—The Pottsville formation consists largely of hard sandstone and is one of the three principal mountain-making formations in the area. It underlies or crops out in practically all of the area that is in the Appalachian Plateaus province, but in the Ridge and Valley province it crops out only on high ridges that surround the Broad Top and Wellersburg coal basins. It forms the extensive flat summits of the plateau over most of northern Clinton County, northeastern Clearfield County, and northwestern Centre County. It underlies most of Cambria and Somerset Counties but crops out along the Allegheny Front, Negro Mountain, and Laurel Ridge.

As described on a preceding page, only sediments of upper Pottsville age were deposited in this area, as the land stood above sea level during lower and middle Pottsville time. Thus the Pottsville is relatively thin in this area, and ranges in thickness from only 130 feet in Cambria County to 375 feet in southern Somerset County. The Pottsville rests unconformably on the eroded surface of the Mauch Chunk or the Ponoco formation.

Three subdivisions of the Pottsville are recognized over most of the area—from top to bottom the Homewood sandstone member, the Mercer shale member, and the Connoquenessing sandstone member.

The Homewood sandstone member generally consists of white or light-gray massive coarse-grained sandstone. In a few places it is conglomeratic, and in some exposures it is colored by iron stains. Locally in Clearfield County, and perhaps in other places, the Homewood may be represented largely by shale. The Homewood ranges in thickness from 15 to 100 feet. It is quarried for building stone in some places.

The underlying Mercer shale member consists of shale and clay, with which locally one or more thin coal beds are associated, but the character and thickness vary considerable from place to place. Locally it contains beds of flint clay, which are of considerable economic importance in the northern part of the area. The coals generally are not workable. In the Broad Top Basin and in southern Somerset County these beds have been called "Mount Savage group." The Mercer ranges in thickness from about 8 to 40 feet.

The Connoquenessing sandstone is the lowest member of the Pottsville in most of the area that lies west of the Allegheny Front. It is generally a hard coarse gray thick-bedded sandstone, but in some places it is white and fine-grained. In most places it contains thin layers of gray sandy shale, and, like most other Carboniferous sandstones, it is replaced entirely by sandy shale in some places. It is locally conglomeratic, and in a few places it is split into two parts by the thin Quakertown coal and associated shale and fine clay. The Connoquenessing along the Allegheny Front ranges in thickness from 95 to 150 feet; in the Broad Top Basin, sandstones below the Mercer member total 115 feet.

Ground-water conditions.—The Homewood and Connoquenessing sandstone members of the Pottsville are probably the most productive water-bearers in the plateau province except in Clinton County, where the Pottsville crops out only on the forested summits of the plateau. The Pottsville has not been exploited in the Ridge and Valley province.

In Clearfield, Cambria, and Somerset Counties and northern Centre County the Pottsville crops out in forested ridges, where it receives abundant recharge, and underlies most of the inhabited valley areas, where the water contained in it is generally under considerable artesian head. Some of the wells flow as much as 40 gallons a minute, including nos. 1 and 31, Clearfield County; no. 97, Centre County; and no. 925, Somerset County. Spring 44, in Clearfield County, which flows about 40 gallons a minute from the Pottsville is probably an artesian spring. Many of the wells that are pumped yield 100 gallons a minute or more, and about a dozen yield from 200 to 400 gallons a minute. Well 31, in Clearfield County, which is only 107 feet deep, was reported to have yielded 832 gallons a minute, with a draw-down of only 25 feet after 8 hours of pumping, and was pumped regularly at 300 gallons a minute.

In places where the Pottsville is deeply buried beneath synclinal coal basins it may yield saline or salty water. Water of this type was reported in well 3, Clearfield County, which is 300 feet deep.

On the basis of 6 analyses (summarized on p. 80) and numerous reports, the Pottsville waters seem to be generally of poor quality. Two-thirds of the samples contained an excess of iron, individual analyses showing as much as 28 parts per million. Moreover, most of the Pottsville waters contain iron in amounts sufficient to produce a red precipitate. In addition, most of the

waters are rather hard, and some contain hydrogen sulphide. It is unfortunate that so productive a water-bearer generally yields water so poor.

Allegheny formation

General features.—The Allegheny formation conformably succeeds the Pottsville. In the plateau province it crops out in and underlies large areas in Clearfield, Cambria, and Somerset Counties and crops out in small areas in northern Centre and Clinton Counties. In the Ridge and Valley province it crops out only in the Broad Top coal field and in southeastern Somerset County. The Allegheny formation consists of a variable sequence of beds of sandstone, shale, limestone, clay, and coal, and the great value of the coal and to a lesser extent the fire clay gives the area its chief source of mineral wealth. Its top member is the Upper Freeport coal, shown in plate 17, B, and its basal member is the shale that generally underlies the Brookville coal and clay. The Allegheny is even more variable in lithology and stratigraphy than any other formation of the Pennsylvanian series. Shale generally constitutes the greater part of the formation, and the sandstones may grade laterally into shale within relatively short distances. In this area the Allegheny ranges in thickness from 220 to about 350 feet but is generally 250 to 300 feet thick.

Subdivisions.—The seven principal coal beds of the Allegheny are known throughout western Pennsylvania and in the Broad Top coal field by the following names, in order from top to bottom:

Principal coals of the Allegheny formation

Western Pennsylvania	Broad Top coal field
Upper Freeport or E coal.....	Kelly coal.
Lower Freeport or D coal.....	Dudley coal.
Upper Kittanning or C' coal.....	Barnettstown coal.
Middle Kittanning or C coal.....	Twin coal.
Lower Kittanning or B coal.....	Barnett coal.
Clarion or A' coal.....	{ Scrubgrass coal.
	{ Fulton coal.
Brookville or A coal.....	Gordon coal.

Generally not all these coals are workable at any one locality, but each is workable in certain localities. The intervals between the coals in the Broad Top Basin are occupied principally by sandstone but also by shale, sandy shale, and clay. In the plateau province many of the beds between the coals have been named and traced over large areas, but most of them vary greatly in thickness and character within short distances and in some places

are absent. The geologic folios describing different quadrangles in the plateau province contain structure-contour maps representing the top of one of the important coals or some other key bed, and these maps were used freely in determining the geologic horizons at which many wells in the Pennsylvanian rocks obtain water.

The Brookville coal is generally underlain by a few feet of shale. In the interval between the Brookville and Clarion coals are found, in ascending order, the Clarion sandstone member, which is 70 feet in maximum thickness, and the Clarion clay or flint clay. In some areas the Clarion sandstone includes sandstones above the Clarion coal.

The Kittanning sandstone member, which reaches 80 feet in thickness, and the overlying Lower Kittanning clay occupy the interval between the Clarion and Lower Kittanning coals. The Vanport limestone member may underlie the Lower Kittanning coal locally in Somerset County but appears to be absent elsewhere.

Between the Middle and Upper Kittanning coals are the Johnstown limestone member and the Upper Kittanning clay. The Llanfair sandstone member, 40 feet in maximum thickness, occurs locally in southwestern Cambria County above the Middle Kittanning coal. The Middle Kittanning clay underlies the coal of the same name.

In the interval between the Upper Kittanning and Lower Freeport coals are found locally the Freeport sandstone member (Lower Freeport sandstone of some reports), which is as much as 40 feet thick in some places, the Lower Freeport limestone member, and the Lower Freeport clay.

The remaining interval between the Lower and Upper Freeport coals includes locally, from bottom to top, the Butler sandstone member, as much as 40 feet thick, the Bolivar fire clay, the Upper Freeport limestone member, and the Upper Freeport clay (Bolivar fire clay of some reports).

Ground-water conditions.—The Allegheny formation appears to be a good water-bearer in areas in the plateau province sufficiently removed from active coal mining, but it has not been exploited in the Broad Top field. The most productive beds are the Butler, Kittanning, and Clarion sandstone members, from which several wells in places where these sandstones are present in sufficient thickness obtain 50 to 150 gallons a minute. Some of these wells flow, such as no. 421, Cambria County. The Llanfair sandstone member is not as widely distributed as the others, and no data

were obtained regarding its water-bearing capacity. Most of the wells in the Allegheny tap beds of shale—the predominant constituent—and these wells generally yield small supplies of water sufficient for household use. Wells 860 and 921, Somerset County, are examples of wells in the Allegheny from which the water has been drained by coal mining.

On the basis of 7 analyses summarized on page 80, most of the Allegheny waters contain more than 100 parts per million of dissolved solids, and one sample (no. 392, Cambria County) contained more than 1,000 parts. Only one sample contained as much as 0.1 part per million of iron, but iron in excess of this amount and hydrogen sulphide were reported in several wells in the Allegheny. However, iron in troublesome amounts appears to be less widespread in the Allegheny waters than in those of the underlying Pottsville formation. Wells 7 and 8, in Clearfield County, and 435, in Cambria County, are examples of wells in the Allegheny that were abandoned because the waters were unfit for use owing to their acidity or salinity. (See also the discussion of water in coal and in coal mines on pp. 51-53.)

Conemaugh formation

General features.—The Conemaugh formation includes the beds that lie between the Upper Freeport coal, at the top of the underlying Allegheny formation, and the Pittsburgh coal, at the base of the overlying Monongahela formation. It is conformable on the Allegheny. It crops out in the same general areas as the Allegheny formation, except that it is absent from Clinton County and is represented in Centre County by only a few thin remnants.

The Conemaugh formation consists of a variable sequence of sandstone, shale, clay, thin coals (a few of workable thickness locally), and thin beds of limestone. It contains beds of red shale—the first above those of the Mauch Chunk shale—and thin marine limestones. Where fully exposed in Cambria and Somerset Counties, the Conemaugh varies in thickness but reaches a maximum of about 870 feet in the Johnstown basin. In Clearfield County and northern Cambria County only 300 to 600 feet has been preserved from erosion, and even less remains in Centre County. Its thickness in the Broad Top field is placed by Gardner ⁷⁴ at only about 533 feet, but it is believed by Ashley ⁷⁵ and Sisler ⁷⁶ to be much thicker.

⁷⁴ Gardner, J. H., The Broad-Top coal field of Huntingdon, Bedford, and Fulton Counties: Pennsylvania Topog. and Geol. Survey Comm. Rept. 10, p. 25, pl. 3, 1913.

⁷⁵ Ashley, G. H., Bituminous-coal fields of Pennsylvania: Pennsylvania Geol. Survey, 4th ser., Bull. M 6, part 1, p. 130, 1928.

⁷⁶ Sisler, J. D., Bituminous-coal fields of Pennsylvania: Pennsylvania Geol. Survey, 4th ser., Bull. M 6, part 2, p. 282, 1926.

Subdivisions.—The Conemaugh formation, like the Allegheny, has been subdivided into a large number of members, but the identity of members that have been given the same names in widely separated areas is not always well established. The thin fossiliferous limestones are probably the best key beds for correlation. The intervals between named beds are generally occupied by shale or sandy shale, locally containing thin limestones and coal streaks.

In the plateau province the basal part of the Conemaugh is the Mahoning sandstone member, with a maximum thickness of 100 feet or more but represented in some localities by shale. In many places the Mahoning is divided into an upper and a lower sandstone by the thin Mahoning coal and associated clay, which occur about at the middle. Locally beds of red shale or limestone or iron ore are associated with the Mahoning coal. A view of the upper sandstone of the Mahoning is shown in plate 11, A.

The next named bed above the Mahoning is a thin coal generally called the Brush Creek coal but known locally in Cambria County as the Gallitzin coal. In some places the Brush Creek coal is overlain by the thin Brush Creek limestone member.

The Buffalo sandstone member occurs above the Brush Creek members. It is 40 to 80 feet thick in some places but absent in other places, where it is represented by sandy shale or shale.

Between the Buffalo member and the overlying Saltsburg sandstone member occur, in ascending order, the Cambridge limestone member, the Bakerstown coals, and associated clays and shales. The Saltsburg, which lies about 300 feet above the base of the Conemaugh, is 20 to 80 feet thick in many places, but, like the other Conemaugh sandstones, it is locally absent.

Between the Saltsburg member and the Ames limestone member—a thin but persistent fossiliferous bed about 400 feet above the base of the Conemaugh—are found locally, in ascending order, the Maynardier coal, beds of red shale called in some reports the Pittsburgh Reds, the Ewing (?) limestone member, and the Harlem coal.

The Morgantown sandstone member, about 300 feet below the top of the Conemaugh, is 30 to 60 feet thick in many places but is locally represented by sandy shale or shale. The strata between the Morgantown and the underlying Ames limestone consist of nearly 200 feet of shale with thin beds of sandstone, fire clay, limestone, and coal seams, some of which bear local names in different localities.

In Somerset County the remaining strata of the upper Conemaugh contain, in ascending order, the Clarksburg limestone member and associated thin coals, the Connellsville sandstone member, as much as 50 feet in thickness but absent locally, and the Upper Pittsburgh limestone member, with which are associated in places the Little Pittsburgh coal and the Lower Pittsburgh limestone member. The uppermost Conemaugh beds consist of shale, locally 50 feet thick. These beds apparently do not extend northward into Cambria County.

In southern Cambria County the strata above the Morgantown contain locally two thick sandstones about 60 feet apart, the lower one, the Summerhill sandstone member, as much as 60 feet thick, and the upper one, the Wilmore sandstone member, as much as 30 feet thick. The strata above the Wilmore consist chiefly of shale and thin beds of sandstone. In northern Cambria County and Clearfield County there are generally no outstanding members recognized above the Morgantown, and the strata consist of a heterogeneous succession of shale, with thin sandstones, limestones, and coals, some of which have been correlated doubtfully with beds to the southwest.

In the Broad Top field some of the Conemaugh coals have been correlated with those of western Pennsylvania, and others have been given local names. The Mahoning sandstone member is also recognized, but the other beds have not been named. In a general way the Conemaugh in this field is similar to that west of the Allegheny Front, but, as mentioned above, the upper limit of the Conemaugh is somewhat in doubt.

Ground-water conditions.—The Conemaugh formation is a productive water-bearer in Cambria and Somerset Counties in places where one or more of its sandstone members are present beneath drainage level. The two lower members, the Mahoning and Buffalo sandstones, appear to be the most productive, and about a dozen wells in these beds had reported yields of 100 to 250 gallons a minute, the largest yield being reported from well 436, Cambria County. (See also well 887, Somerset County.) A few of the wells flow.

The Saltsburg and Morgantown sandstone members are above drainage level in most places where large quantities of ground water are used, but several wells in the Morgantown (nos. 426, 427, Cambria County, and 924, Somerset County) had reported yields of 50 to 90 gallons a minute. The Summerhill and Wilmore sandstone members occur only locally, generally above drainage

level, and no wells were observed tapping them. A few domestic wells tap the Connellsville sandstone member.

Other beds in the Conemaugh, chiefly shale, generally yield small supplies for domestic use and in a few places enough for industrial use. The Conemaugh is relatively unimportant in Clearfield County and has not been exploited in the Broad Top field.

As very little coal is mined from the Conemaugh, as compared to the underlying Allegheny formation, there is much less danger of loss or pollution of its ground waters by mining operations.

Analyses of 11 samples of ground water from the Conemaugh are summarized on page 80. Most of the samples analyzed contained 100 to 225 parts per million of dissolved solids, but the total range was 68 to 641 parts. Three samples contained iron in excess of 0.1 part per million, and excess iron was reported in several other wells, but the Conemaugh waters appear to contain much less iron than those of the Pottsville. In general the Conemaugh waters are satisfactory for most ordinary uses.

Monongahela formation

General features.—The Monongahela formation, which includes all the strata between the base of the Pittsburgh coal and the top of the Waynesburg coal, reaches a thickness of 400 feet in southwestern Pennsylvania, but it has been removed by erosion from most of the area described in this report. It is conformable on the Conemaugh formation. Several small isolated remnants of the Monongahela are found in southeastern and northern Somerset County, in southern Cambria County, and in the Broad Top field. In some of these outcrops as much as 100 feet of the Monongahela remains, but the thickness is generally much less. Gardner⁷⁷ held that possibly the entire Monongahela (445 feet thick) and a portion of the overlying Dunkard group are present in several high knobs in the Broad Top field, but according to Ashley⁷⁸ and Sisler,⁷⁹ much of this may belong to the Conemaugh, so that the thickness of the Monongahela and the presence of beds younger than the Monongahela in this field appear to be still in doubt. Thus the Monongahela is definitely the youngest Paleozoic formation in the area immediately west of the Allegheny Front, and the same appears to be true in this area east of the Front.

⁷⁷ Gardner, J. H., op. cit. (Pennsylvania Topog. and Geol. Survey Comm. Rept. 10), pp. 25, 28, pl. 3.

⁷⁸ Ashley, G. H., op. cit. (Pennsylvania Geol. Survey, 4th ser., Bull. M 6-1), p. 130.

⁷⁹ Sisler, J. D., op. cit. (Pennsylvania Geol. Survey, 4th ser., Bull. M 6-2), p. 282.

The remaining Monongahela strata present in Cambria and Somerset Counties include the important basal Pittsburgh coal (2 to 9 feet thick), locally the Redstone coal and possibly higher coals, and associated strata of shale, clay, sandstone, and limestone.

Ground-water conditions.—The Monongahela formation is unimportant as a source of ground water in this area, and no wells were observed on its meager outcrops. The water-bearing properties of the Monongahela in southwestern Pennsylvania, where it crops out over large areas, have been described by Piper.⁸⁰

TRIASSIC SYSTEM

Diabase

In southeastern Perry County four diabase dikes trending northeast cut through all the sedimentary rocks from the Ordovician to the Mississippian. (See pl. 1.) Intrusive sheets and dikes of diabase are common in the Triassic basins of southeastern Pennsylvania, but so far as is known the dikes mentioned above are the only ones that penetrate the area described in this report.

As described by Claypole,⁸¹ the diabase is a hard, very tough dark heavy fine-grained rock containing grains of magnetite. The rock disintegrates readily in the weathered zone. The dikes are nearly vertical, range in thickness from 5 or 10 feet up to 200 feet in some places, and trend in nearly straight lines. The adjacent sediments have been somewhat altered and hardened in many places.

The water-bearing properties of diabase are given on pages .

TERTIARY (?) SYSTEM

Terrace deposits

Deposits of ancient stream gravel found at several places along the Juniata River above Huntingdon are believed by Butts⁸² and by Leverett⁸³ to be of late Tertiary age. A conspicuous example is found on the hills north of Huntingdon, where scattered stream-worn pebbles of sandstone and quartzite from 2 to 5 inches in diameter lie at an altitude of 1,060 feet, or about 400 feet above the present level of the Juniata River. These deposits are very thin and are unimportant as sources of ground water.

⁸⁰ Piper, A. M., Ground water in southwestern Pennsylvania: Pennsylvania Geol. Survey, 4th ser., Bull. W 1, pp. 144-156, 1933.

⁸¹ Claypole, E. W., A preliminary report on the paleontology of Perry County, describing the order and thickness of its formations and its folded and faulted structure: Pennsylvania Second Geol. Survey, Rept. F2, pp. 293-302, 316, 317, 1885.

⁸² Butts, Charles, unpublished report on the Tyrone quadrangle, Pa.

⁸³ Leverett, Frank, Glacial deposits outside the Wisconsin terminal moraine in Pennsylvania: Pennsylvania Geol. Survey, 4th ser., Bull. G 7, pp. 60, 61, 1934.

QUATERNARY SYSTEM

PLEISTOCENE SERIES

General features.—This part of Pennsylvania was not covered by ice during the last or Wisconsin stage of glaciation, but the Wisconsin ice sheet stopped not far northeast of the area, and Wisconsin outwash is found in the northeastern part of the area. However, the northeast corner of the area was covered by at least two earlier advances of ice, the Jerseyan and Illinoian, as far as the limits shown on plate 1. The following description of these deposits is taken largely from a recent report by Leverett.⁸⁴

Pre-Illinoian or Jerseyan drift.—Scanty deposits of deeply weathered till and scattered erratics found in the northeastern part of the area and believed to have resulted from one or possibly two pre-Illinoian glaciations are thought to represent the Jerseyan drift. Deposits of this kind, including some of questionable origin, have been found along the West Branch of the Susquehanna River near Lock Haven at an altitude of more than 1,000 feet, or 400 feet above the river, and in Union and Snyder Counties at altitudes of 700 to 900 feet. Similar deposits have been traced along Penns Creek as far west as Weikert, Union County, and along Middle Creek as far west as Rager Summit, near McClure, Snyder County. Scanty gravel deposits believed to be Jerseyan outwash are found along the Susquehanna River between Selinsgrove and Harrisburg at points 200 feet above the present river.

Williams⁸⁵ believed that the West Branch of the Susquehanna and Bald Eagle Valleys were dammed by the pre-Illinoian ice to a sufficient height for the impounded water ("Glacial Lake Lesley") to discharge across a pass at Dix, Blair County, at an altitude of about 1,100 feet. Leverett,⁸⁶ however, could discover no evidence in support of such a glacial spillway and found that the valley in the vicinity of the pass was strewn with gravel and sand brought in by two small streams, Big Fill Run and California Hollow.

No mention is made by Leverett of the depth or extent of pre-Illinoian glacial scouring in the valley of the West Branch of the Susquehanna in Clinton and Lycoming Counties. The writer has found evidence from the records of wells in the valley that the river flows over a buried valley in most places between Lock Haven and Muncy. Several wells close to the river penetrated as

⁸⁴ Leverett, Frank, *idem*, pp. 19-63.

⁸⁵ Williams, E. H., Notes on the southern ice limit in eastern Pennsylvania: *Am. Jour. Sci.*, 3d ser., vol. 49, pp. 174-185, map, 1895.

⁸⁶ Leverett, Frank, *op. cit.*, pp. 57, 58.

much as 125 feet of sand, gravel, and silt, and one higher up ended in gravel at a depth of 135 feet. The filling of the old valley by unconsolidated material may have taken place prior to the Illinoian glaciation and ponding discussed below, but below Williamsport there was probably additional scouring by the Illinoian lobe, and filling of the valley during the Illinoian ponding. Wisconsin outwash later added more material. These deposits are discussed below under "Ground-water conditions."

Illinoian drift.—Lobes of the Illinoian glacier are believed to have extended up the West Branch of the Susquehanna River beyond Williamsport and down as far as Allenwood, and another lobe is believed to have extended down the North Branch of the Susquehanna to a point southwest of Selinsgrove. The Illinoian drift is a reddish, highly oxidized clayey material with only a few thin pockets of sand or gravel. The most conspicuous morainic deposits are found in the Illinoian terminal moraine west of Selinsgrove, where there are numerous knolls as much as 10 feet high and depressions 3 to 5 feet deep. Illinoian outwash gravel has been found along the Susquehanna River below Selinsgrove at points 60 to 150 feet above the river, and at several places along the West Branch.

The Susquehanna River appears to have been dammed by Illinoian ice at several places, and deep ponds or lakes resulted. Thus the West Branch appears to have been ponded up to 150 feet above present river level between Allenwood and an ice dam near Sunbury, and water from this lake may have spilled over into Penns Creek through a pass about 580 feet above sea level between Winfield and New Berlin.

A similar dam across the West Branch in the vicinity of Muncy produced a large lake extending along the Susquehanna and Bald Eagle Valleys through Lycoming County and into Clinton County some distance above Lock Haven. The evidence indicates ponding to a height of about 135 feet above present river level. During the period of this ponded condition several streams that cut through Bald Eagle Mountain built huge alluvial fans in the Susquehanna Valley, notably Antes Creek, in Lycoming County, and McElhattan Creek, in Clinton County.

Well-defined terraces, thought to be of Illinoian age, are found at many places along the Juniata River between Tyrone and Duncannon at heights of 80 to 160 feet above the river. These deposits are entirely fluvial, as the Juniata Basin has not been glaciated. Similar terraces of sand and gravel, which may be largely fluvial, were observed by the writer along the West Branch

of the Susquehanna in Clinton County between Renovo and Lock Haven and along Young Womans Creek at North Bend.

Wisconsin drift.—The Wisconsin glacier did not reach any part of the area covered by this report, but during its recession the swollen southward-flowing streams between Pine Creek in Clinton County and the North Branch of the Susquehanna at Sunbury carried considerable sand, silt, and gravel into the Susquehanna River. Terraces of Wisconsin outwash are found 60 feet above Pine Creek at its mouth and at heights of about 40 feet above the Susquehanna River along the entire eastern border of the area covered by this report.

Ground-water conditions.—The Pleistocene deposits appear to be good water-bearers only along the West Branch of the Susquehanna in Clinton County and at a few places along the Susquehanna at the eastern border of the area.

The Jerseyan drift is generally thin and unimportant as a source of water. The Illinoian drift along the Susquehanna and the Illinoian terrace deposits along the Juniata are relatively unimportant, but they may supply a few shallow dug wells.

The deposits filling the valley of the West Branch of the Susquehanna as far up as Lock Haven, in Clinton County consisting of a mixture of lake and outwash deposits of Jerseyan, Illinoian, and Wisconsin age, are an important source of ground water. They have not been exploited to any great extent in Clinton County but furnish large supplies in Lycoming County, as will be described in a forthcoming report on north-central Pennsylvania. A shallow dug well in these deposits at Mill Hall (no. 216) was reported to yield 1,000 gallons a minute during a test. The maximum known thicknesses of these deposits are 125 feet in well 221 and 135 feet in well 237, and as numerous beds of sand and gravel were encountered in these wells, large supplies of water could probably be obtained by means of properly constructed wells using well screens. Samples of water collected from two wells in these deposits indicate good average waters except for an excess of iron. (See analyses 202 and 232, Clinton County.)

Sand, gravel, and clay from 25 to 90 feet in thickness are reported from some wells along the Susquehanna River in Snyder and Union Counties, but in all wells observed these deposits were cased off. Moderate supplies of water might be obtained from the deposits in some places. At Selinsgrove, however, where the maximum thicknesses were reported, the material is chiefly clay or till of the Illinoian terminal moraine.

The sand and gravel deposits along the West Branch above Lock Haven have been utilized to some extent in the vicinity of Gleasonston and Renovo. (See wells 198, 202, and 204, Clinton County.) Between Hyner and Renovo as much as 40 to 65 feet of sand and gravel is reported from wells.

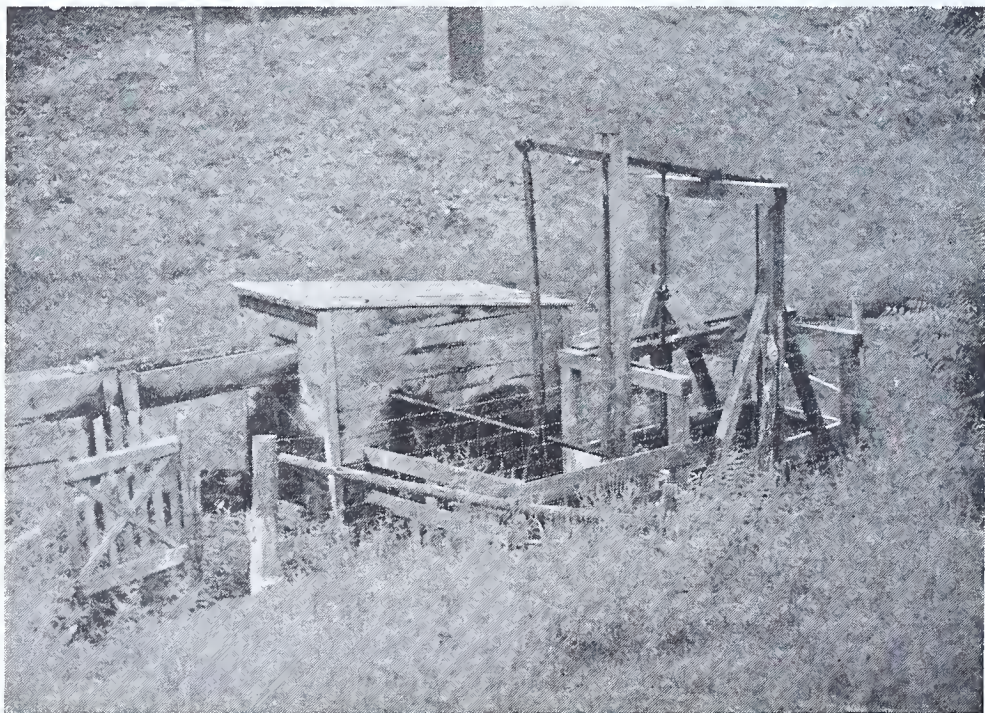
RECENT SERIES

Alluvium

Recent deposits of silt, sand, and gravel are found along all the streams and rivers, but in most parts of the area they are thin and unimportant as sources of ground water. A part of this material is derived from the disintegration of the bedrocks by rain, frost, wind, and stream erosion, and a part is derived from the reworking of the Pleistocene series described above.

Dug or driven wells obtain small supplies of water from the alluvium in many of the larger stream valleys. The city of DuBois is built upon a deeply alluviated valley known as "The Meadows," and the alluvium is 60 feet thick in some places. The DuBois Brewing Co. has several dug wells that obtain water from these recent gravel deposits. (See well 11, Clearfield County.)

Plate 17



Home-made two-cylinder force pump operated by overshot water wheel supplied by spring 506 at Royer, Blair County. Utilizes a small part of the discharge of a large tubular spring to supply farm on hilltop.

COUNTY DESCRIPTIONS

COUNTY DESCRIPTIONS

In the pages that follow, the geography, geology, and ground-water conditions are described briefly by counties in alphabetic order, with descriptions of public and local supplies derived from ground water, tables of representative wells and springs, well logs, and chemical analyses of ground water.

The wells, springs, and other sources of ground-water supplies shown on plate 2 are numbered consecutively from 1 to 1173 in order of counties from northwest (Clearfield County) to southeast (Fulton County). In each county the wells are numbered consecutively from north to south and are tabulated by townships. The wells in some of the boroughs are arbitrarily included in the surrounding or nearest township. The same numbers are used to identify the logs and chemical analyses of waters.

The information pertaining to many of the wells was obtained from well drillers. These wells were located on topographic or base maps from the drillers' descriptions, and nearly all such locations were checked in the field. It is possible, however, that a few of the wells are not accurately located. Altitudes given are taken from the nearest contour or benchmark on the topographic maps published by the United States Geological Survey unless otherwise indicated. Wells and springs for which no altitudes are given are situated in quadrangles for which no topographic maps are available.

It was not practicable to make many measurements of depths and water levels, because most of the wells listed are drilled wells covered with pumps. Most of the data are taken from statements of drillers or owners, and only a few of the drillers have kept written records. The figures on depth to water level are probably the least accurate of those given in the tables, as most of the drillers and owners relied on memory in supplying this information. The depths to water level in the observation wells that are measured periodically are believed to be accurate (pl. 9). The data pertaining to most of the industrial and public supplies were taken from written records and are therefore more accurate than those pertaining to most of the domestic supplies.

Information given for public supplies concerns only those supplies that are derived from ground water, either as a sole source or as an auxiliary source.

BEDFORD COUNTY

Area 1,026 square miles. Population (1930) 37,309.

GEOGRAPHY

Bedford County, the fourth largest county in the area, is sparsely populated and mountainous and contains only about 37 inhabitants to the square mile, as against 215 for the entire State. Agriculture is the principal industry, and about 65 percent of the total land area of the county is devoted to farming. Bedford, Everett, Hyndman, and Saxton are the only boroughs in the county having 1,000 or more inhabitants, and Bedford, with a population of 2,953 in 1930, is the largest. According to the Federal census of 1929, there were 56 manufacturing establishments in the county whose products were valued at \$5,000 or more annually, principally near the Broad Top coal field, at the northeast corner of the county, along the Lincoln Highway, which traverses it from east to west, and along the Baltimore & Ohio Railroad, whose main line crosses the southwest corner of the county. Part of the Broad Top coal field is within this county. There are several resorts along the Lincoln Highway, the largest of which is the Bedford Springs Hotel and Baths, just south of Bedford.

The topography is characteristic of the Ridge and Valley province. Blue Knob, with an altitude of 3,136 feet, is the highest point in the county. Allegheny Mountain, in the northwest corner, rises to an altitude of more than 2,800 feet in several places; Kinton Knob, on Wills Mountain, has an altitude of 2,642 feet; and Tussey Mountain and Evitts Mountain rise above 2,500 feet. Wills Creek crosses the Maryland State line at an altitude of about 740 feet—the lowest point in the county. The total relief is therefore nearly 2,400 feet.

The northern two-thirds of Bedford County is drained by the Raystown Branch of the Juniata River, a stream noted for its striking meanders. In a straight-line distance of less than 40 miles from Everett to the mouth in Huntingdon County, the stream flows in a channel about 85 miles long.⁸⁷ A small area in the northwest corner is drained by the Frankstown Branch of the Juniata River, and the southern third of the county is drained by Wills Creek and other tributaries of the Potomac River. The western boundary is part of the Continental Divide, and a small part of the drainage flows into the headwaters of the Ohio River Basin.

⁸⁷ Stone, R. W., Meanders in Raystown Branch of Juniata River: *Pennsylvania Acad. Sci. Proc.*, vol. 9, p. 74, 1935.

GEOLOGY

The rocks exposed in Bedford County range from the Warrior limestone, of Upper Cambrian age, to the Conemaugh or Monongahela formation, of Pennsylvanian age (pl. 1). Their character and water-bearing properties are described in the first half of this report. The oldest rocks, the Cambrian and Ordovician limestones and dolomites, are exposed by the Nittany anticline and occupy two large fertile valleys—Morrisons Cove and Friends Cove. The youngest rocks, of the Pennsylvanian series, crop out in the Broad Top coal field, at the northeast corner of the county, and in part at several places on the western boundary. Nearly two-thirds of the county is underlain by Devonian strata. The numerous steep ridges in the central part are formed by the Tuscarora quartzite and on the eastern and western boundaries by the Pocono formation. The principal folds trend northeast.

GROUND WATER

The Cambrian and Ordovician limestones and dolomites, the limestones and calcareous shales of the Cayuga group, the Helderberg limestone, and the Ridgeley sandstone appear to be the most productive water-bearers in the county. Except for the Ridgeley these rocks form valleys, and it is in the valleys that ground water is used most extensively. Ground water is used in Bedford County principally for domestic purposes and stock, very little being used by industries and almost none for public supply.

In most parts of the county rural and village water supplies are obtained largely from dug wells, but springs and drilled wells also supply many homes. There is relatively little alluvium in any of the valleys, and most of the dug wells obtain water from soil and disintegrated rock. Cisterns are used extensively in Morrisons Cove, Friends Cove, and perhaps other limestone valleys, and by most of the homes in Woodbury.

Springs are numerous, particularly in the limestone valleys, but most of the springs observed yield less than 100 gallons a minute. Those at Bedford Springs Hotel and Baths (nos. 991 and 994) were estimated to yield 30 to 100 gallons a minute. The water from Magnesia Spring has a bitter taste and is said to have laxative properties. A sample of this water contained 2,565 parts per million of dissolved solids, had a hardness of 1,994 parts (chiefly calcium and magnesium sulphate), and was the hardest and most highly concentrated sample collected in these 14 counties. Spring 964, at Spring Meadow, supplies the Reynoldsdale State Fish Hatchery with 1,800 gallons a minute of clear, cold water well suited for growing fish (analysis 964). A spring

near Shellsburg is reported to yield 1,000 gallons a minute, and there are several large springs in Friends Cove.

There is very little industrial use of ground water in Bedford County. A few drilled wells furnish water for cooling in ice or milk plants, the strongest of which is well 988, in Bedford.

The weekly water levels in an unused dug well at Saxton (no. 938) are shown in plate 9, and a view of the Saxton well is shown in plate 8, B.

Only five flowing wells were observed in the county (nos. 987, 1016, 1021, 1042, and 1058), all of which flow only a small amount. There appear to be no areas where numerous strong flowing wells might be expected.

The quality of ground waters from several geologic formations in the county is shown by the analyses of 8 samples given below. Most of the ground waters in the county are satisfactory for ordinary use except waters in parts of the Cayuga group and in the Helderberg limestone, which are generally too hard for most purposes but are satisfactory for cooling or drinking. (See analyses 988 and 992.) None of the 8 samples contained enough iron to be troublesome. A few waters from the Reedsville and other dark shales give off small quantities of hydrogen sulphide gas. The quality of water to be expected from the different geologic formations is summarized on pages 80-81.

PUBLIC SUPPLIES

There are relatively few public water supplies in Bedford County, and all of them use surface water. They serve Bedford, Centerville (Bedford Valley p.o.), Everett, Evitts, Hyndman, Manns Choice, Rainsburg, Riddlesburg, and Saxton. The Cumberland City Reservoir, which supplies Cumberland, Md., is in Cumberland Valley Township, Bedford County.

The Bedford Borough Water Co. has one flowing drilled well (no. 987) that flows a small quantity of water into its reservoir.

The Bedford Springs Hotel and Baths have a private water supply derived from Black Spring (no. 994), and three other springs used for drinking, bottling, and bathing (nos. 991-993).

Typical wells and springs in Bedford County

No. on pl. 2	Location	Owner or name	Topographic situation	Altitude (feet) ^a	Type of supply ^b	Depth (feet)	Diameter (inches)	Principal water-bearing bed				Length of casing (feet)	Depth to water level (feet)	Method of lift ^c	Yield (gallons a minute)	Use of water ^f	Remarks
								Depth to top of bed (feet) ^e	Thickness (feet)	Character of material ^d	Geologic horizon						
928	Union Township 0.4 mile northwest of Pavia	Homer Christ.....	Valley	1,450	Dr	50	6	NB	(?)	Red ss. and sh. do.	Catskill.....	20	15±	I	3-5	D	Drilled wells in Pavia average about 50 feet in depth.
929	Pavia.....	J. C. Dibert.....	do.	1,440	Dr	62	6	50	(?)		do.	20	15±	S	5	D	
930	Kimmell Township Queen.....	Kimmell Township School	Slope	1,300	Dr	50	6	NB	(?)	Shale.....	Portage.....	40	10±	I	3-5	D	Water reported hard.
931	1.2 miles east of Queen	S. Eneigh.....	Hillside	1,260	Dr	44	6	NB	(?)	Limestone....	Onondaga.....	40	5±	H	3-5	D	
932	Bloomfield Twp. 0.8 mile north of Baker Summit	Harry Appleman....	Valley	1,420	Dr	120	6	NB	(?)	do.	Warrior.....	?	50±	H	5±	C,D	Used for cooling milk.
933	do.	do.	do.	1,420	Dr	70	6	66	4	Channel in ls..	do.	63	4 to 70	N	0-9	N	
934	2.0 miles northwest of Maria	C. F. Eifler.....	do.	1,370	Dr	48	6	NB	(?)	Limestone....	do.	25	24±	P	5±	D	Water level -4 feet in winter, but well is dry in summer. 63 feet of clay cased.
935	1.4 miles west of Maria	C. F. Furry.....	Slope	1,440	Dr	165	6	160	2	Channel in ls..	do.	100	22±	H,P	5±	D	
936	Woodbury Twp. Woodbury.....	Woodbury High School	Hillside	1,320	Dr	104	6	NB	(?)	Channel in dol.	Beekmantown	?	40±	P	5±	D	Reported small draw- down at 9 gallons a minute.
937	do.	L. Carl Barkman....	do.	1,240	Dr	49	6	NB	(?)	Dolomite.....	do.	20	15±	I	3-5	D	

938	Liberty Township Saxton.....	Mr. Breneman.....	do.	920	Du	58	48	NB	(?)	Shale.....	Chemung.....	58	22 to 52	N	?	N	U. S. Geological Survey observation well. (See pl. 9.) Pumps dry at 1½ gallons a minute; now use city water.
939	do.	Huntingdon & Broad Top R. R.	do.	880	Dr	200	6	(?)	(?)	do.	do.	?	30 ±	N	1 ±	N	
940	Broad Top Twp. Riddlesburg.....	W. Carberry.....	do.	900	Dr	90	6	NB	(?)	Red shale....	Mauch Chunk	50 ±	50 ±	P	5 ±	D	Temperature 50°F. See analysis.
941	Hopewell.....	Lloyd McIny.....	do.	920	Dr	98	6	NB	(?)	do.	do.	?	?	H	3-5	D	
942	Hopewell Township 0.2 mile southeast of Lehighbergertown	Moose Club.....	Slope	900	Dr	50	6	NB	(?)	Yellow shale...	Portage.....	20	22 ±	H	3 ±	D	
943	0.3 mile west of Lehighbergertown	Bill Troutman.....	Hillside	960	Dr	50	6	NB	(?)	Black shale....	Marcellus....	?	30 ±	H	3-5	D	
944	0.2 mile west of Yellow Creek	Burkett.....	Valley	960	Dr	35 ±	6	NB	(?)	Red shale....	Bloomsburg ..	20	20	H	3-5	D	
945	Yellow Creek.....	Yellow Creek Ice Plant	do.	950	DD	34	6	27	7	do.	do.	27	8 ±	S	10+	C, I	Used for cooling and ice making but not for boiler. Temperature 55°F. See analysis.
946	2.1 miles southwest of Yellow Creek	Grant Ritchie.....	do.	1,060	Dr	41	6	(?)	(?)	Limestone....	Tonoloway....	?	15 ±	H	3-5	D	
947	0.9 mile north of Tatesville	Will Foor.....	Hillside	1,180	Dr	85	6	NB	(?)	Cavernous limestone	Helderberg or Cayuga	60	25 ±	H	5 ±	D	Channels in limestone contain clay, water muddy. Located on or near a fault.
948	South Woodbury Township Waterside.....	O. A. Holsinger.....	Valley	1,180	DD	27	6	NB	(?)	Dolomite.....	Beekmantown	12+	10 ±	I	8	D	Reported draw-down 3 feet.
949	1.3 miles east of Lafayetteville	Ross Bowser.....	do.	1,390	Dr	85-90	4	80 ±	(?)	Limestone or dolomite	Beekmantown or Upper Cambrian	80 ±	?	W, P	5 ±	D	Channels contained sand and mud down to 80 feet.
950	1.5 miles northwest of New Enterprise	Herman Furry.....	do.	1,360	Dr	90	6	70	20	Gravel.....	do.	90	80 ±	P	7	D, Ir	90 feet of clay, sand, and boulders above limestone or dolomite. Lower 20 feet of casing perforated.
951	New Enterprise...	J. B. Snowberger...	do.	1,250	Dr	50	6	NB	(?)	Dolomite.....	Beekmantown	35	15 ±	I	5 ±	D	Many cisterns used in town.

Typical wells and springs in Bedford County—Continued

No. on pl. 2	Location	Owner or name	Topographic situation	Altitude (feet) ^a	Type of supply ^b	Depth (feet)	Diameter (inches)	Principal water-bearing bed				Length of casing (feet)	Depth to water level (feet)	Method of lift ^e	Yield (gallons a minute)	Use of water ^f	Remarks
								Depth to top of bed (feet) ^c	Thickness (feet)	Character of material ^d	Geologic horizon						
952	1.3 miles south of New Enterprise	Jerry Detwiler.....	Hillside	1,340	Dr	245	6	NB	(?)	Dolomite.....	Beekmantown	(?)	195±	P	5±	D, S	Yield increased after charge of dynamite.
953	0.3 mile north of Salemville	Lloyd King.....	Valley	1,300	Dr	30	6	NB	(?)	Limestone....	Trenton or Carlisle	8	?	H	3-5	D	
954	0.7 mile northwest of Salemville	Mrs. John Bowser...	Hillside	1,340	Dr	80	6	NB	(?)	do.	do.	50±	?	H, P	10+	D, S	Channels contained mud down to 50 feet.
955	King Township																
955	Imlet.....	G. Mock.....	do.	1,210	Dr	50	6	(?)	(?)	Black shale....	Onondaga.....	8±	20±	H	3-5	D	
956	0.3 mile southeast of Weyant post office	H. W. Ickes.....	Slope	1,260	Dr	50	6	NB	(?)	Hard gray sh..	Portage.....	16	15±	H	3-5	D	
957	0.4 mile northwest of Osterburg	Andrew Claycomb...	Hillside	1,200	Dr	100	6	NB	(?)	Sandstone....	Ridgeley.....	74	68±	H	5±	D	
958	0.3 mile northwest of Osterburg	Lawrence Imlet.....	Ridge	1,320±	Dr	233	6	NB	(?)	do.	do.	(?)	200±	N	(?)	N	Drilled to supply Osterburg but never used because of 200-foot lift. Reported large yield of soft water.
959	0.2 mile north of Osterburg	J. C. Godhnour.....	Valley	1,150	Dr	59	6	NB	(?)	Limestone?...	do.	(?)	20-	S	7	D	Water hard and contains excess iron; has to be filtered.
960	West St. Clair Twp. 1.2 miles southeast of Ogletown (Felix post office)	John Lochre.....	Ridge	2,640	Dr	116	6	35±	81±	Sandstone....	Pocono.....	(?)	35±	H	5±	D	Reported small draw-down on bailing 35 gallons a minute. Water reported excellent.
961	Pleasantville (Alumbank post office)	Walter Davis.....	Valley	1,240	DD	68	6	NB	(?)	Dark shale....	Portage.....	40	10	I	3-5	D	Many dug wells in town dry in summer of 1933; this well drilled deeper.

962	1.3 miles southeast of Pleasantville	Herman Felix.....	do.	1,140	Dr	57	6	40	17	Dark brown ss.	Ridgeley.....	25	3	I	5±	D	Reported draw-down 7 feet on bailing about 50 gallons a minute.
963	do.	H. M. Kells.....	do.	1,140	Dr	50	6	NB	(?)	Black shale....	Marcellus or Onondaga	25	12	H	5±	D	Reported draw-down about 8 feet on bailing 40 or 50 gallons a minute for 1½ hour.
964	East St. Clair Twp.																
964	Spring Meadow...	Reynoldsdale State Fish Hatchery	do.	1,125	Sp					Sandstone....	Ridgeley.....			F	1,800	F	Temperature 53°F. See analysis. Yield measured by owner.
965	do.	Mrs. R. H. Hoskins..	do.	1,130	Dr	56	6	30	26	Sandy shale...	do.	30	4±	S	5	D, S	Reported draw-down about 6 feet on bailing 40 gallons a minute for ½ hour.
966	do.	do.	Hillside	1,140	Dr	109	6	NB	(?)	Sandstone....	do.	(?)	?	P	5±	D	
967	2.1 miles north of Cessna	E. Helsel.....	Ridge	1,350	Dr	165+	6	NB	(?)	(?)	Shriver.....	(?)	?	P	3-5	D	
968	1.2 miles north of Cessna	George Kimmell.....	do.	1,290	Dr	140	6	NB	(?)	Sandy shale...	do.	140	?	H	3-5	D	
969	Springlope.....	Rob Brant.....	Hillside	1,260	Dr	70	6	NB	(?)	Hard ss.....	Ridgeley.....	45	35±	H, P	5±	D	Water reported muddy.
970	do.	P. Herschberger.....	do.	1,260	Dr	52	6	(?)	(?)	Blue shale....	Onondaga....	15	15±	H	3±	D	
	Napier Township																
971	New Paris.....	Dan Hillman.....	do.	1,300	Dr	90	6	(?)	(?)	Sandstone....	Ridgeley.....	(?)	?	H	5±	D	
972	0.2 mile northeast of Millertown (Helixville)	Mr. Snowberger....	Ridge	1,880	Dr	50	6	NB	(?)	Yellow shale..	Chemung.....	10±	10±	H	3-5	D	80-foot well at barn
973	1.1 miles northwest of Point	Fred Dennison.....	Hillside	1,490	Dr	225	6	199±	26±	Limestone....	Shriver.....	199	165±	P	5±	D	
974	0.7 mile west of Point	J. N. Williams.....	do.	1,290	Dr	65±	6	55±	10±	Sandstone....	Ridgeley.....	(?)	60±	H, P	5	D	
975	Schellsburg.....	C. B. Kulp.....	do.	1,290	Dr	185	8	180	5	Hard ss.....	do.	18	100±	P	5	D	Supplies two families
976	do.	Harry Hull.....	Slope	1,220	Dr	25	6	NB	(?)	Black shale....	Marcellus.....	20	6±	H	3±	D	
977	1.3 miles southwest of Schellsburg	Leon Falk.....	do.	1,350	Dr	194	6	NB	(?)	Crevice in ss..	Ridgeley.....	15	100±	P	25	D, S	Reported small draw-down.
978	1.1 miles south of Schellsburg	Oscar Diehl.....	Hillside	1,200	Dr	50	6	NB	(?)	Blue shale....	Portage.....	(?)	10±	H	3-5	D	
	Bedford Township																
979	1.0 mile north of Belden	Stockton.....	Valley	1,080	Dr	58	6	NB	(?)	Limestone....	Wills Creek...	20	10±	H	5±	D	
980	0.8 mile west of Belden	Bedford Township School	Hillside	1,180	Dr	60-65	6	NB	(?)	do.	do.	15±	30±	H	5±	D	Water reported 'rusty'.
981	0.2 mile west of Belden	George Williams estate	Valley	1,100	Dr	50	6	NB	(?)	do.	do.	10±	30±	H	3-5	D	

Typical wells and springs in Bedford County—Continued

No. on pl. 2	Location	Owner or name	Topographic situation	Altitude (feet) ^a	Type of supply ^b	Depth (feet)	Diameter (inches)	Principal water-bearing bed				Length of casing (feet)	Depth to water (feet)	Method of lift ^c	Yield (gallons a minute)	Use of water ^f	Remarks
								Depth to top of bed (feet) ^e	Thickness (feet)	Character of material ^d	Geological horizon						
982	0.2 mile northeast of Imletown	Calvin Steffier.....	Hillside	1,180	Dr	55	6	?	(?)	Blue shale....	Onondaga....	20	3±	H	3-5	D	Shale overlain by 100 feet of loose sand- stone.
983	1.5 miles southwest of Imletown	W. Bradeham	do.	1,200	Dr	140	6	100	40	do.	Shriver.....	100	100	H	3-5	D	
984	0.5 mile northeast of Yount	J. L. Russell.....	Valley	1,080	Dr	36±	6	?	(?)	(?)	Portage.....	(?)	?	H	3±	D,S	
985	Yount.....	Charles Yount.....	Hillside	1,100	Du	19	30±	11	8	Dark shale....	Chemung.....	11	7.5 to 18	N	(?)	N	U. S. Geological Sur- vey observation well, discontinued October 1934; see pp. 36-39.
986	Wolfsburg.....	D. R. Smith.....	Slope	1,110	Dr	50	6	NB	(?)	Black shale....	Clinton.....	(?)	30±	H	3±	D	Flows into reservoir.
987	0.6 mile west of Bedford	Bedford Borough Water Co.	Hillside	1,250	Dr	240	8	NB	(?)	Red shale or sandstone	do.	(?)	+	F	1 to 5	P	Larger yield if pumped.
988	Bedford.....	Supplee-Wills-Jones Milk Co.	Valley	1,070	Dr	180	8	NB	(?)	Limestone....	Wills Creek...	40	22±	P	60	C,I	Reported small draw- down. Temperature 54°F. See analysis. Not used for boilers.
989	do.	McLaughlin Handle Factory	Slope	1,090	Dr	100	6	NB	(?)	do.	do.	20	14±	N	13	N	
990	0.6 mile northeast of Bedford	Charles Bagley	do.	1,100	Dr	73	6	NB	(?)	Sandstone....	Oriskany.....	40	20±	H	7-8	D	40 feet of loose sand- stone cased.
991	0.1 mile east of Bedford Springs	Bedford Springs, Hotel and Baths	Hillside	1,100	Sp					Limestone....	Helderberg....			F	100+	?	Temperature 52°F.
992	Bedford Springs...	Bedford Springs, Hotel and Baths,	do.	1,100	Sp					do.	do.			F	30±	M,D	Water has bitter taste. Temperature 60°F. See analysis.
993	0.3 mile south of Bedford Springs	Magnesia Spring Bedford Springs, Hotel and Baths,	do.	1,140	Sp					do.	do.			F	40±	B	Temperature 55°F.
994	1.0 mile south of Bedford Springs	Still House Spring Bedford Springs, Hotel and Baths, Black Spring	do.	1,180	Sp					do.	Tonoloway....			F	40±	P	Main hotel supply Temperature 53°F.

995	1.2 miles southwest of Bedford Springs	James Kileoin.....	Ridge	1,420	Dr	408	6	NB	(?)	do.	Helderberg....	80	378±	N	?	N	Formerly supplied sawmill. Reported large yield. Upper 125 feet is soft sandstone. Lower 20 feet is shale.
996	3.1 miles southwest of Bedford Springs	Thomas Easter.....	Hillside	1,320	Dr	120	6	100	(?)	Sandstone....	Oriskany.....	100	100±	H	5±	D	
997	1.1 miles northeast of Burning Bush	George Leonard.....	do.	1,400	Dr	97	6	NB	(?)	Shaly ls.....	Tonoloway?..	(?)	48±	H	3-5	D	
998	0.9 mile northeast of Burning Bush	Frank Kegg.....	do.	1,340	Dr	38	6	NB	(?)	do.	do.	10	6±	H	3-5	D	
	Snake Spring Twp.																
999	0.3 mile north of Foreman	Howard Wyles.....	Hillside	1,360	Dr	85±	6	NB	(?)	Shale.....	Reedsville....	40	30±	H	3-5	D	
1000	1.9 miles north of Valley Mill	Ellis Van Horn.....	do.	1,160	Dr	90	6	NB	(?)	Crevice in limestone	Trenton or Carlin	12	40±	P	5±	D	Pumped mud when first drilled but cleared rapidly.
1001	1.6 miles north of Valley Mill	Milbert Snyder.....	Valley	1,120	Dr	55	6	NB	(?)	Limestone....	do.	4	18 to 30	S	7	S	
1002	0.4 mile north of Valley Mill	John Snyder.....	do.	1,100	Dr	58	6	50	8	Channel in ls..	do.	18	28	H	10±	D	Channel 8 feet deep.
1003	Valley Mill.....	J. Hershberger.....	do.	1,080	Dr	80	6	NB	(?)	Limestone or dolomite	Carlin or Beckmantown	6-8	30±	P	5±	D,S	
1004	1.3 miles east of Willow Grove	Lee Foreman.....	Hillside	1,200	Dr	167	6	160	7	Dolomite.....	Beckmantown	160	92±	P	5	D	160 feet of clay cased.
1005	0.5 mile east of Willow Grove	O. C. Hartley, Bubbling Spring	Valley	1,120	Sp	.....	.....	.....	.....	do.	do.	.....	.....	P	100±	D	Total yield from two openings. Temperature 52°F. See analysis.
1006	Willow Grove.....	Mrs. Wilson Amick..	Hillside	1,180	Dr	146	6	NB	(?)	Limestone....	Trenton.....	10	50	H	3±	D	
1007	0.5 mile northwest of Lutzville	John Snouse.....	do.	1,100	Dr	90	6	90	(?)	Channel in dolomite	Beckmantown	90	79±	H	5±	D	Reported that several wagonloads of sand pumped out before water cleared.
1008	0.5 mile southeast of Lutzville	Ross Read.....	Valley	1,040	Dr	35	6	35	(?)	do.	do.	20	15±	H	5±	D	
1009	0.8 mile southeast of Lutzville	Harry England.....	Hillside	1,100	Dr	92	6	90.5	1.5	do.	do.	2	25±	H	5±	D	
1010	0.9 mile south of Lutzville	Harry Mortimer.....	do.	1,130	Dr	69	6	NB	(?)	do.	do.	29	30±	H	5±	D	
1011	0.9 mile south of Ashcom	Jesse Roek.....	do.	1,200	Dr	132	6	.....	.....	Solid limestone	Trenton or Carlin	12	.....	N	O	.....	Unfinished; dry hole at 132 feet. To be used for household if successful.

Typical wells and springs in Bedford County—Continued

No. on plat.	Location	Owner or name	Topographic situation	Altitude (feet) ^a	Type of supply ^b	Depth (feet)	Diameter (inches)	Principal water-bearing bed				Length of casing (feet)	Depth to water level (feet)	Method of lift ^c	Yield (gallons a minute)	Use of water ^f	Remarks
								Depth to top of bed (feet) ^e	Thickness (feet)	Character of material ^d	Geologic horizon						
1012	West Providence Township Everett	G. H. Gibney Planing Mill	Hillside	1,080	Dr	397	6	.....	.....	Yellow clay (fault gouge?)	Helderberg or Cayuga	257	.....	N	0	N	Some water in gravel at 97 feet; dry below. Located on or near fault.
1013	do.	Everett Borough Water Co.	Valley	1,060	Dr	500	6	50, 150, 200	(?)	Crevice in limestone	do.	18	?	A	30	N	Formerly used for public supply. Reported draw-down 230 feet on pumping only 30 gallons a minute.
1014	0.5 mile east of Everett	Everett Cemetery Association	Hillside	1,060±	Dr	100	6	NB	(?)	Shale	Portage	50	30 to 50	H	3-5	Ir	60 feet of loose sand cased.
1015	0.2 mile south of Everett	Dan Bachman	Valley	1,020	Dr	75	6	NB	(?)	Sandstone	Oriskany	60	40±	P	5±	D	
1016	do.	Scott Beach	do.	1,040	Dr	28	6	NB	(?)	Blue shale	Onondaga	6±	+3±	F	2±	D	
1017	0.3 mile south of Everett	Ira Klingerman	do.	1,040	Dr	87	6	74	13	Black shale	Marcellus	74	13±	H	3-5	D	Water reported hard and to contain excess iron.
1018	do.	Simon Weight	Hillside	1,060	Dr	105	6	104.5	0.5	Channel in ls.	Helderberg	20	50±	H	5±	D	
1019	3.2 miles east of Everett	M. L. Read	Valley	1,010	Dr	97	6	NB	(?)	Red sandstone	Chemung	(?)	?	P	3-5	D	
1020	1.2 miles southeast of Everett	Chester Ritchey	Hillside	1,100	Dr	60	5	NB	(?)	Soft yellow sh.	Portage	10	20±	H	3±	D	
1021	2.1 miles southwest of Everett	William Weight	Valley	1,080	Dr	33±	6	NB	(?)	Dark shale	Marcellus	6-8	+	F	1-2	D	
1022	2.7 miles south of Everett	Frank O'Neil	Ridge	1,440	Dr	60	6	NB	(?)	Blue shale	Portage	20	10±	H	4	D	
1023	Mench	Mrs. W. C. Slonacher	Hilltop	1,280	Dr	110	6	NB	(?)	Red shale	Chemung	20	40±	H	1	D	
1024	0.6 mile northeast of Mench	Vaugh Williams	Hillside	1,220	Dr	142	6	NB	(?)	do.	do.	20	18±	H	3±	D	
1025	2.2 miles south of Mench	A. V. Conner	Hilltop	1,420	Dr	86	6	NB	(?)	Red sh. and ss.	Catskill	45±	?	H	3-5	D	
1026	2.3 miles south of Mench	do.	Hillside	1,180	Dr	50±	6	NB	(?)	Red shale	do	(?)	(?)	H	3-5	D	

	East Providence Township	George H. Gilney...	Ridge	1,180±	Dr	192	6	NB	(?)	Red sandstone	Chemung.....	20	92±	W,P	9	D	Location not checked.
1027	2.1 miles west of Brezewood.....	do.	Hilltop	1,350	Dr	55	6	NB	(?)	Red shale.....	do.	20	?	H	3-5	D	
1028	Brezewood.....	M. N. Saly.....	do.	1,350	Dr	82	6	NB	(?)	do.	do.	(?)	40±	H	3-5	D	
1029	do.	Floyd Ritchie.....	Hillside	1,570	Dr	80	6	NB	(?)	do.	Catskill.....	35	40±	H	5±	D	
1030	1.4 miles east of Brezewood.....	do.	do.	1,440	Dr	90	6	NB	(?)	Red sandstone	do.	(?)	?	H	3-5	N	Do.
1031	1.9 miles south of Brezewood.....	Chester Wilk.....	Upland	1,330	Dr	125	6	NB	(?)	do.	Catskill or Chemung	20	45±	P	1	D	
1032	1.2 miles southwest of Brezewood.....	Russell Melloy.....	Ridge	1,230	Dr	187	6	NB	(?)	Red and brown sandstone	Chemung.....	20	50±	P	1	S	
1033	2.8 miles west of Brezewood.....	Upton Bennet.....	do.	1,260	Dr	86	6	NB	(?)	Red shale.....	Catskill or Chemung	17	50±	H	1±	D, S	
1034	2.8 miles northwest of Capsville.....	Ray Hand.....	do.	1,200	Dr	90	6	NB	(?)	do.	Catskill.....	(?)	?	H	2-3	D	
1035	2.0 miles northwest of Capsville.....	John B. Hand.....	do.	1,300	Dr	132	6	NB	(?)	do.	do.	(?)	?	H	2-3	D	
1036	do.	Morgan Clark.....	Hillside	1,200	Dr	120	6	NB	(?)	do.	do.	(?)	?	H	3-5	D	
1037	2.1 miles south of Meuch.....	Elton Williams.....	do.	1,460	Dr	100	6	NB	(?)	Red sh. and ss.	Chemung.....	(?)	40±	H	3-5	D	
1038	Mattie.....																
	Monroe Township																
1039	Clearville.....	Lynnan Grove.....	do.	1,410	Dr	80		NB	(?)	Red sandstone	Catskill.....	20	40±	H	3-4	D	
1040	do.	John Koontz.....	do.	1,410	Dr	40	5	NB	(?)	Blue shale....	do.	(?)	?	H	7-8	D	
1041	0.7 mile southeast of Clearville.....	Charles Diehl.....	Canyon	1,360	Dr	52	6	NB	(?)	Red shale....	Catskill or Chemung	10	25±	H	1	D	
1042	1.9 miles south of Clearville.....	Cecil Miller.....	Hillside	1,360	Dr	60	6	NB	(?)	Yellow shale..	Chemung.....	15	+2	1	5±	D, S	Flows a small amount.
1043	Clearville.....	Reynolds Fisher.....	Valley	850	Dr	30	6	NB	(?)	(?)	Catskill.....	(?)	15±	H	3±	N	Pump broken.
	Coderain Township																
1044	0.9 mile northwest of Ott Town.....	Shannon Beagel.....	Hillside	1,280	Dr	190	6	189	1	Channel in dolomite	Beckmantown	189	180±	H	5±	D	Many clay-filled channels in rock, cased.
1045	0.7 mile west of Ott Town.....	Bob Beagel.....	do.	1,250	Dr	116	6	100	0.5±	do.	do.	40	100±	H	1-2	D	Reported pumped dry in half an hour at 3 gallons a minute.
1046	0.4 mile northeast of Charlesville.....	Emory Kegg.....	Slope	1,340	Dr	112	6	NB	(?)	Limestone....	Trenton-Carlton	10±	50±	H	1-2	D	
1047	Charlesville.....	Friends Cove Fire Insurance Co.	do.	1,320	Dr	53	6	NB	(?)	do.	do.	(?)	?	H	1	D	Pumps dry in half an hour during summer.
1048	1.0 mile north of Rainsburg.....	Ellis Whitestone.....	Valley	1,290	Dr	35	6	35	(?)	Channel in dolomite	Beckmantown	8	15±	H	3-5	D	Many cisterns used in Friends Cove.
1049	0.3 mile northeast of Rainsburg.....	John Diehl.....	Slope	1,340	Dr	35	6	35	(?)	Channel in ls. or dolomite	Carlton or Beckmantown	8	15±	H	3-5	D	

Typical wells and springs in Bedford County—Continued

No. on pl. 2	Location	Owner or name	Topographic situation	Altitude (feet) ^a	Type of supply ^b	Depth (feet)	Diameter (inches)	Principal water-bearing bed				Length of casing (feet)	Depth to water level (feet)	Method of lift ^c	Yield (gallons a minute)	Use of water ^f	Remarks
								Depth to top of bed (feet) ^e	Thickness (feet)	Character of material ^d	Geologic horizon						
1050	0.3 mile east of Rainsburg	George Russler.....	Slope	1,390	Dr	45	6	45	(?)	Channel in limestone	Trenton.....	30	20±	H	3-5	D	Water contains hydro- gen sulphide and forms a white pre- cipitate. Tempera- ture 52° F. See analy- sis. Another spring 0.4 mile south. Water reported to con- tain excess iron.
1051	Rainsburg.....	Carl Fisher.....	do.	1,340	Dr	97±	6	NB	(?)	Channel in dol. do.	Beekmantown do.	40	50±	H	5±	D	
1052	0.9 mile northwest of Rainsburg	Housel.....	do.	1,320	Dr	40	6	NB	(?)			15±	15±	H	3-5	D	
1053	Harrison Township Sulphur Spring.....	M. S. Colvin..... White Sulphur Spring	Valley	1,360	Sp					Shale.....	Reedsville.....			F	3.5	D	Very little water above 385 feet. Small draw - down. See analysis. Abandoned oil and gas test. All fresh water cased off above 1,600 feet. Some salt water reported at 4,000 feet. Another test nearby 1,100 feet deep hit fresh water at bottom. Location not checked.
1054	Buffalo Mills.....	Harry Brown.....	Valley	1,310	Dr	55	6	NB	(?)	Limestone?...	Onondaga or Oriskany	(?)	?	H	3-5	N	
1055	Bard.....	H. A. Corley.....	do.	1,280	Dr	37.5	6	37.5	(?)	do.	do.	37.5	7	I	3-5	D	
1056	Juniata Township Grand View.....	Herbert Paulsen, (Grand View Hotel)	Hillside	2,440	Dr	400	8	385	5	Gray ss.....	Pocono.....	40	365	P	35	D	Very little water above 385 feet. Small draw - down. See analysis. Abandoned oil and gas test. All fresh water cased off above 1,600 feet. Some salt water reported at 4,000 feet. Another test nearby 1,100 feet deep hit fresh water at bottom. Location not checked.
1057	1.7 miles southwest of Schellsburg	Mike Hillegas.....	Valley	1,220	Dr	4,222	6	4,000	(?)	Sandstone?...	Tuscarora or Juniata	1,600	(?)	N	?	N	
1058	1.3 miles northwest of New Buena Vista	Straub Bros.....	Hillside	1,640	Dr	38	6	NB	(?)	Red shale.....	Chemung.....	(?)	+ & -	H	1-3	D	Location not checked.
1059	New Buena Vista... New Buena Vista...	H. E. Whisker.....	Slope	1,300	Dr	135	6	NB	(?)	Blue shale.....	Portage.....	14±	18±	H	3±	N	

1060	1.1 miles east of Kegg West End.....	Mrs. H. Curley.....	Valley	1,240	Dr	70	6	NB	(?)	Dark shale....	Chemung.....	10	?	H	3±	D
1061		Richard Girdell.....	Saddle	1,830	Dr	60±	6	NB	(?)	Yellow shale...	do.	(?)	?	H	3±	D
	Londonerry Twp.															
1062	Fossilville.....	De Witt Deal.....	Valley	1,060	Dr	76.5	6	NB	(?)	Dark sandy sh.	Hamilton.....	23	10	H, I	5	D
1063	Palo Alto.....	Russell Emerick.....	do.	900	Dr	27	6	NB	(?)	Limestone....	Helderberg....	12	?	I	3-5	D
1064	0.2 mile southeast of Palo Alto....	Roy Albright.....	Hillside	930	Dr	81.5	6	NB	(?)	do.	Oriskany or Helderberg	5	67±	P	5±	D
1065	0.7 mile west of Cooks Mills	D. F. Deal.....	Valley	810	Dr	116	6	NB	(?)	Cherty ls.....	Oriskany.....	5	6±	I	3-5	D
1066	1.2 miles southwest of Cooks Mills	Virgil Lowry.....	Canyon	820	Dr	76	6	NB	(?)	Shale.....	Marcellus.....	10.5	18±	H	3-5	D
1067	do.	Henry Ford.....	Valley	770	Dr	27	6	NB	(?)	Sandstone....	Oriskany.....	(?)	10±	I	3-5	D
	Cumberland Valley Township															
1068	2.2 miles northeast of Centerville (Bedford Valley post office)	Morgan Oliver.....	do.	1,200	Dr	64	6	NB	(?)	Red sandstone	Bloomsburg..	4	20±	H	3-5	S
1069	1.9 miles east of Centerville	Jose Oliver.....	Hillside	1,320	Dr	103±	6	100	3±	Sandstone....	Oriskany.....	(?)	50±	H	1-3	D
1070	Centerville.....	S. R. Nave.....	Slope	1,200	Dr	65±	6	NB	(?)	Limestone....	Cayuga.....	10±	15±	H	3-5	D
1071	2.4 miles northeast of Cooks Mills	Albert Height (tenant)	Hillside	1,020	Dr	49	6	NB	(?)	Calcareous sh.	do.	22	13±	H	3-5	D
1072	2.1 miles east of Cooks Mills	E. J. Smith.....	do.	980	Dr	27	6	NB	(?)	Limestone....	do.	10	12±	S	7-8	D
1073	3.2 miles east of Cooks Mills	C. J. Steelberg.....	do.	960	Dr	44	6	NB	(?)	Black shale....	Marcellus	10	14±	H	3-5	D
	Southampton Twp.															
1074	Chaneyville.....	Ben Leasure.....	Valley	1,020	Dr	36	6	NB	(?)	Shale.....	Hamilton.....	20	10±	H	3±	D
1075	Hewitt.....	R. G. McElfish.....	do.	890	Dr	59	6	NB	(?)	Dark blue sh..	Hamilton or Marcellus	25	25±	H	3-5	D
1076	2.0 miles northeast of Flintstone, Md.	Walter Wakefeld....	do.	900	Dr	40+	6	NB	(?)	Limestone....	Cayuga.....	(?)	?	H	3±	D
1077	2.2 miles northwest of Artemas	A. L. Tool.....	Hillside	1,420	Dr	120	6	NB	(?)	Shale.....	Portage.....	10	45±	H	3-5	D
	Mann Township															
1078	1.3 miles northwest of Artemas	Fred Collins.....	Hillside	1,220	Dr	108	5	NB	(?)	Blue shale....	Portage.....	20	58±	H	6	D

Location not checked.

Location not checked.
Reported draw-down
20 feet at 6 gallons
a minute.

Typical wells and springs in Bedford County—Continued

No. on pl. 2	Location	Owner or name	Topographic situation	Altitude (feet) ^a	Type of supply ^b	Depth (feet)	Diameter (inches)	Principal water-bearing bed				Length of casing (feet)	Depth to water level (feet)	Method of lift ^c	Yield (gallons a minute)	Use of water ^f	Remarks
								Depth to top of bed (feet) ^e	Thickness (feet)	Character of material ^d	Geologic horizon						
1079	Purell.....	G. F. Smith.....	Valley	850	Dr	12	6	NR	(?)	Shale.....	Chemung.....	(?)	6±	I	3±	D	Has another well 53 feet deep. Both wells ruined by oil from road.
1080	1.2 miles north of Inglesmith	Ed Cooper.....	do.	840	Dr	49	6	NB	(?)	Red sandstone	Catskill.....	8	10±	N	1-2	D	
1081	0.2 mile east of Inglesmith	Christian church parsonage	Ridge	1,070	Dr	145	6	NB	(?)	Red shale....	do.	20	105±	H	1±	D	Well 64 feet deep at house.
1082	0.2 mile south of Inglesmith	Albert Smith.....	Hillside	1,020	Dr	112	6	NB	(?)	Red sandstone	do.	(?)	12±	H	3±	S	

^a Altitudes taken from nearest contour on topographic map unless otherwise indicated.^b Dr, drilled well; Du, dug well; DD, dug and drilled well; Sp, spring.^c NB, near bottom.^d Dol, dolomite; ls, limestone; sh, shale; ss, sandstone.^e A, air lift; F, natural flow; H, lift pump, hand-operated; I, pitcher pump, hand-operated; N, none; P, force pump, power-operated; S, suction pump, power-operated; W, windmill.^f C, condensing or cooling; B, bottling; D, domestic; F, fish hatchery; I, industrial; Ir, irrigation; M, medical baths; N, none; P, public supply; S, stock.

Partial analyses of ground waters from Bedford County

[Analyzed by E. W. Lohr. Parts per million. Number at heads of columns refer to corresponding numbers in the preceding table and on pl. 2.]

	940	945	964	988	992	1,005	1,053	1,056
Calcium (Ca).....	a 24	86	a 50	226	558	a 60	a 30	a 10
Magnesium (Mg).....		9.4		77	146			
Sodium and potassium (Na+K) (calculated).....	8	b	2	7	b	b	8	45
Bicarbonate (HCO ₃).....	112	256	83	235	183	278	143	147
Sulphate (SO ₄).....	a 4	a 20	104	659	1,764	a 12	a 20	24
Chloride (Cl).....	1.0	11	.4	12	6.0	2.0	2.0	2.0
Nitrate (NO ₃).....	5.2	11	1.8	.80	.20	16	.0	.70
Total dissolved solids (calculated).....	108	264	218	1,098	2,565	274	151	160
Total hardness as CaCO ₃	84	c 254	174	881	c 1,994	255	123	50
Date of collection (1933).....	Oct. 13	Oct. 13	Oct. 12	Oct. 13	Oct. 13	Oct. 13	Oct. 13	Oct. 12

a By turbidity.

b Less than 5.

c Calculated.

BLAIR COUNTY

Area 535 square miles. Population (1930) 139,840.

GEOGRAPHY

Blair County is one of the smaller counties in the area but ranks second to Cambria County in density of population, with about 261 inhabitants to the square mile, as against 215 for the entire State. The population is largely urban, and more than half the people live in Altoona, which, with 82,054 inhabitants in 1930, is the largest city in the entire area covered by this report. Tyrone has 9,042 and Hollidaysburg 5,969 inhabitants, and five other boroughs have from 1,200 to 2,700. About 45 per cent of the total land area is devoted to agriculture, and the most prosperous farms are in the fertile limestone valleys. Coal is mined along the western boundary, and considerable limestone the ganister rock are quarried (pp. 13, 14 and pl. 6, B). In 1929 there were in the county 147 manufacturing establishments each of whose products were valued at \$5,000 or more annually, nearly half of which are in Altoona. Altoona is on the main line of the Pennsylvania Railroad, whose large shops there constitute the most important industry in Blair County. The William Penn Highway traverses the county a few miles south of Altoona.

The highest point in the county is in the western corner of Freedom Township, where part of Allegheny Mountain has an altitude of more than 3,000 feet. The Frankstown Branch of the Juniata River crosses the Huntingdon County line at an altitude of about 720 feet, the lowest point in the county. The maximum relief is therefore about 2,280 feet. The Allegheny Mountains form the western boundary and rise 2,500 to 3,000 feet above sea level. Other ridges in the central and eastern parts of the area stand at altitudes of 2,300 to 2,600 feet. The topography is characteristic of the Ridge and Valley province.

The western boundary forms part of the Continental Divide, and except for the headwaters of a few small streams that drain toward the Ohio River, the county is drained entirely by the Juniata River. The northern part is drained by the Little Juniata River, and the southern part by the Frankstown Branch of the Juniata.

GEOLOGY

The rocks exposed in Blair County range from the Waynesboro formation, of Lower Cambrian age, to the Conemaugh formation, of Pennsylvanian age (pl. 1). There are small amounts of Pleistocene gravel and Recent alluvium along the major streams. The character and water-bearing properties of these formations are

described in the first half of this report. The oldest rocks, the Cambrian and Ordovician limestones and dolomites (pls. 6, B, and 12, B) are exposed by the Nittany anticline and form the large fertile connected limestone valleys in the eastern part of the area—Sinking Valley (the southern tip of Nittany Valley,) Canoe Valley, and Morrisons Cove. The large valley on the west, in which Tyrone, Bellwood, Altoona, and Hollidaysburg are situated, is underlain by Devonian strata and is separated from the eastern valleys by a long, sinuous ridge of Tuscarora quartzite. The youngest rocks crop out along the western boundary. The principal faults in the limestone valleys are mentioned on pages 28, 29. The principal folds trend northeast.

GROUND WATER

The water-bearing formations that appear to be most productive in Blair County are the Cambrian and Ordovician limestones and dolomites, Clinton formation, Cayuga group, Helderberg limestone, Shriver chert, and Ridgeley sandstone. These are largely valley-forming rocks, although the Ridgeley forms low ridges in some places and the Gatesburg formation makes hilly sandy areas known locally as "The Barrens." In Blair County ground water is used extensively for domestic purposes, stock, and industrial supplies, and a small amount is used for public supply.

The ground water for domestic use is derived largely from springs and dug wells, but in part from drilled wells. The dug wells obtain water principally from soil or decomposed rocks, as there is very little alluvium. Cisterns are used at many places in the limestone valleys.

Ground water for industrial use in the limestone valleys is obtained largely from springs and in the Altoona district from drilled wells. Some of the largest springs in the area are in Blair County, including Cold Spring (no. 472), Arch Spring (no. 476, pl. 12, B), Big Springs (no. 502), spring 506 (pl. 17), and Roaring Spring (no. 529, pl. 16, A). In addition, Big Spring in Tyrone (not listed) has a reported yield of 4,500 gallons a minute. There are numerous smaller springs, some of which are listed in the tables below. Flowing Spring (no. 509) is an unusual type of limestone spring that "ebbs and flows" at regular intervals, as described in detail on page 65. Most of the largest springs are owned by paper companies, which are the largest users of ground water in the county. The Tyrone plant of the West Virginia Pulp & Paper Co. has several sources of water supply, including Bald Eagle Creek, four drilled wells (nos. 464-467), of which two are

used, Hundred Springs in Huntingdon County (no. 546), and as an emergency supply Cold Spring (no. 472). This company's Williamsburg plant is supplied by Big Springs (no. 502). Roaring Spring (no. 529), in the borough of the same name, supplies the D. M. Bare Paper Co., a printing office, and a flour mill and is used as an emergency public supply. (See below.)

In Altoona, Tyrone, and Hollidaysburg considerable ground water is used for cooling by ice and cold storage companies, dairies, ice-cream manufacturers, meat packers, and hotels. The strongest industrial wells for which records are available are in the Tonoloway and Helderberg limestones (nos. 464-466), those in Altoona are in the Helderberg or the Oriskany group (nos. 489, 490, 492-498), and the one well in Hollidaysburg is in the Clinton formation.

Records were obtained of only four flowing wells in Blair County, and they all appear to be in different formations (nos. 486, 478, 516, and 517). Two of these are in a synclinal basin near Loop station, east of Hollidaysburg, and it is possible that there may be others in this vicinity. The flow of all these wells is small.

The analyses of 9 samples of ground water collected from representative wells and springs in Blair County are given below. Most of the waters are of good quality and satisfactory for ordinary use, but some of the limestone waters, particularly from the Cayuga group, are too hard for use in boilers. (See analysis 468.) The sample from well 514, in the Clinton formation, Hollidaysburg, was very hard and also contained considerable sodium chloride (common salt). This appears to be only a local occurrence of diluted connate water. None of the samples contained iron in noticeable amounts. The quality of water to be expected in the different geologic formations is summarized on pages 80, 81.

PUBLIC SUPPLIES

Altoona, Bellwood, Tyrone, Hollidaysburg, and Duncansville are supplied by surface water, principally from numerous small streams along the east slope of the Allegheny Front. Parts of Logan Township are supplied by the Allegheny Water Co. and the Home Water Co.; the former serves surface water, and the latter serves surface water and spring water (no data available on spring). Claysburg, Sproul, and Roaring Spring (in part) are supplied by ground water. The smaller places have no public supplies.

Claysburg is supplied from two springs owned by the General Refractories Co., near the western base of Dunning Mountain.

One of the springs is known as the Weynant Spring (no. 526). The water flows into a small concrete reservoir above Claysburg, from which it is distributed by gravity. About half of the water is used at the plant of the General Refractories Co., and the other half supplies about 400 people. The system also includes several fire plugs. The water is chlorinated. The system is not metered, and the consumption is not known.

Sproul is supplied by the Burket Stake Spring (no. 528), also owned by the General Refractories Co. The spring is walled and contains about 1,300 gallons. The water is conducted from the spring by two centrifugal pumps to two steel tanks above Sproul, each 12 feet high and 12 feet in diameter. Distribution is effected by gravity. One tank supplies the plant of the General Refractories Co., which uses about two-thirds of the water, and the other tank supplies the residents. The water is chlorinated. The system is not metered, and the consumption is not known.

Roaring Springs (population 2,724) is supplied by the borough chiefly from small streams on Dunning Mountain, west of the borough. From a 10,000,000-gallon reservoir on the mountain the water flows by gravity to a 500,000-gallon reservoir in the borough, whence it is distributed by gravity. During the summer and fall, when the streams are too low to furnish all the water needed, water is pumped from Roaring Spring (no. 529) by a steam-driven centrifugal pump operating 3 to 8 hours a day at a rate of 30,000 gallons an hour. There is also a reciprocating pump for use in emergencies. The daily consumption is about 250,000 gallons, chiefly by the inhabitants but in part by a printing office. The average pressure in the borough is about 60 pounds to the square inch. About 50 fire plugs are connected to the system. No treatment of any kind is required for either the stream or spring water. The water from the spring is of good quality, as shown by analysis 529.

Typical wells and springs in Blair County

No. on pl. 2	Location	Owner or name	Topographic situation	Altitude (feet) ^a	Type of supply ^b	Depth (feet)	Diameter (inches)	Principal water-bearing bed				Length of casing (feet)	Depth to water level (feet)	Method of lift ^d	Yield (gallons a minute)	Use of water ^e	Remarks
								Depth to top of bed (feet) ^c	Thickness (feet)	Character of material	Geological horizon						
462	Snyder Township 0.5 mile northwest of Bald Eagle	L. A. Womer.....	Valley	1,080	Dr	50	6	NB	(?)	Shale.....	Harrell.....	41	4±	I	3-5	D	Draw-down 140 feet.
463	0.2 mile northeast of Vail	Standard Oil Co.....	do.	1,000	Dr	67	6	NB	(?)	Sandstone....	Hamilton.....	67	2±	S	3-5	D	
464	Tyrone.....	West Virginia Pulp & Paper Co.	do.	† 917	Dr	350	8	356	6	Channel in limestone do.	Tonoloway....	75	7	T	200	I	Upper 75 feet broken and channeled limestone. After 2 days of pumping creek broke through and ruined well.
465	do.	do.	do.	910	Dr	356	8	356	(?)		Tonoloway? ..	175	6	T	315	N	Upper 75 feet broken and channeled limestone. After 2 days of pumping creek broke through and ruined well.
466	do.	do.	do.	920	Dr	313	10-6	100±	200±	Vertical crevice in limestone.	Helderberg? ..	70	28	T	380	I	10-inch hole, upper 130 feet; rest 6 inches. Reported draw-down 115 feet.
467	do.	do.	do.	910	Dr	330	10	(?)	(?)	Shale.....	Wills Creek....	100	15	N	20-	N	Pumped dry at 20 gallons a minute.
468	do.	C. G. Waple Dairy..	do.	900	Dr	155	6	155	9	Channel in limestone	McKenzie or Wills Creek	20	16	S	50	C	Temperature 54°F. See analysis. Small draw-down.
469	do.	Shaffer Meat Plant..	do.	890	Dr	150	8	NB	(?)	Blue shale....	Clinton.....	28	6	T	30	C	Reported draw-down 50 feet.
470	Nealmont.....	Mr. Vaneman.....	Hillside	900	Dr	85	6	NB	(?)	Limestone....	Trenton.....	51	50±	H	5±	D	Upper part of well penetrates Reedsville shale.
471	Ironville.....	Charles Caffarelli....	do.	900±	Dr	56	6	(?)	(?)	Dolomite.....	Belleville.....	(?)	20±	H	5±	D	Most nearby wells are dug.
472	0.2 mile east of Grazierville	West Virginia Pulp & Paper Co., Cold Spring	Canyon	920	Sp					Limestone....	Helderberg....			F	700-2,000	N	Dammed and provided with overflow channel. Held in reserve, but water reported contaminated. Temperature 52°F. at outlet. Yield measured by owner.

	Tyrone Township	(?)	do.	1,000	Sp						Dolomite.....	Bellefonte.....			F	100±	D	Issues from channel, walled and covered. Temperature 52°F. at outlet. Yield estimated.
473	1.6 miles southwest of Ironville																	
474	1.4 miles northwest of Arch Spring	Clarence Templeton	do.	1,010	Dr	155	6	NB	4		Channel in dolomite	Nittany.....	21	40±	H	5±	D	Water level—85 feet in Nov. 1931. In wet seasons clay is carried through channel but eliminated by raising pump pipe 18 feet. Pumps dry in 1 hour. No large openings encountered.
475	0.9 mile north of Arch Spring	A. W. Templeton.....	Hilltop	1,120+	Dr	126	6	(?)	(?)		Tight dolomite	do.	(?)	60±	P	3	D	
476	0.2 mile southwest of Arch Spring	H. C. Means, Arch Spring	Valley	900±	Sp						Limestone.....	Lowville±.....			F	2,000±	N	Issues from natural arch at east end of sink hole, stream also visible in sink hole 0.7 mile southwest. See pl. 12, B. Yield estimated.
477	0.3 mile east of Scalp Level	Harvey Briggs.....	do.	1,180	Dr	50	6	(?)	(?)		do.	Trenton.....	(?)	20±	P	5±	D	
478	Culp.....	L. E. Cristmore.....	Hillside	1,060	Dr	90	6	NB	(?)		Dolonite.....	Bellefonte....	14	+ (?)	I	5-10	D	Flows a small amount. Crevices at depth of 45 feet and near bottom.
479	do.	Caum Dairy Farm...	do.	1,060	2 Dr	100	?	(?)	(?)		do.	do.	(?)	(?)	P	20±	D, S	Two wells, same depth, same capacity.
480	2.3 miles southwest of Culp	Mrs. Yenter.....	do.	1,240	Dr	80	6	(?)	(?)		(?)	Reedsville or Trenton	(?)	(?)	H	3-5	D	
481	0.5 mile south of Elberta	John Biseli.....	do.	1,940	Du	39	48	NB	(?)		Sandstone.....	Juniata.....	39	30	H	3-5	D	Many springs and a few drilled wells in vicinity.
482	Antis Township																	
482	0.5 mile south of Bellwood	Mr. Laukard.....	do.	1,100	Dr	102	6	NB	(?)		Limestone.....	Helderberg....	77	40±	H	3-5	D, S	
483	0.7 mile south of Bellwood	Roy Cherry.....	do.	1,060	Dr	130	6	NB	(?)		Shaly limestone.	Tonoloway±	116	50±	?	3-5	D, S	
484	0.9 mile southwest of Pincroft	Max Dunmire.....	do.	1,100	Dr	102	6	NB	(?)		Limestone.....	Tonoloway....	45	40±	P	9	D	
485	Logan Township																	
485	Wopsononock.....	Altoona Northern RR	Hilltop	2,480	Dr	200	6	(?)	(?)		Sandstone.....	Pocono.....	(?)	50±	W	20	N	Railroad and well reported abandoned.

Typical wells and springs in Blair County—Continued

No. on pl. 2	Location	Owner or name	Topographic situation	Altitude (feet) ^a	Type of supply ^b	Depth (feet)	Diameter (inches)	Principal water-bearing bed				Length of casing (feet)	Depth to water level (feet)	Method of lift ^c	Yield (gallons a minute)	Use of water ^e	Remarks
								Depth to top of bed (feet) ^d	Thickness (feet)	Character of material	Geologic horizon						
486	Juniata.....	L. S. Peterman.....	Canyon	1,260	Dr	141	8	NB	(?)	Slate.....	Portage.....	21	3	S	5	I,Ir	Would flow but is pro- vided with overflow 3 feet below ground surface.
487	0.8 mile northwest of Newburg	S. Crilly.....	Hillside	1,700	Dr	165	6	NB	(?)	Red shale....	Catskill.....	15	50±	P	5	D	
488	0.6 mile northwest of Newburg	J. G. Bunner.....	do.	1,650	Dr	100	6	NB	(?)	do.	Catskill or Chemung	15±	?	H	3-5	D	
489	Newburg.....	West Altoona Ice Co.	Canyon	1,300	Dr	150	8	NB	(?)	Dark slate....	Portage.....	30	12±	T	30	C	Reported draw-down 110 feet. Tempera- ture 54°F. See analysis.
490	Altoona.....	Penn Alto Hotel.....	Hillside	1,230	Dr	260	8	NB	(?)	Black slate....	do.	30	3	P	22	C	Reported draw-down 30 feet at 15 gallons a minute. Tempera- ture 58°F.
491	Greenwood.....	Orange & Black Tea Room	Valley	1,220	Dr	140	6	NB	(?)	Broken ls.....	Helderberg...	78	73?	P	7	D	
492	Altoona.....	East End Ice Co....	Hillside	1,210	Dr	129	8	129	(?)	Limestone....	Shriver or Helderberg	42	40±	T	60	C	Reported very small draw-down. Hit crevices at bottom.
493	do.	Caums Ice Cream Co.	do.	1,200	Dr	212	8	156±	(?)	Soft sandstone	Ridgeley.....	25	40±	T	250- 300	C,I	Filled with sand up to 156 feet without re- ducing yield. Re- ported draw-down 60 feet. Tempera- ture 53°F. See analysis.
494	do.	Harshburger Dairy Co.	Valley	1,140	Dr	235	8	NB	(?)	Limestone....	Helderberg...	35	30±	P	125	C,I	Limestone below black slate. Reported draw-down 50 to 60 feet. Temperature 53°F.
495	0.7 mile east of Altoona	F. R. McMahon Dairy Co	Hillside	1,150	Dr	555	8	448	(?)	Red shale....	Clinton.....	24	20	P	10	C	Some water in lime- stone at 137 feet.

496	Altoona.....	United Home Meat Co.	Valley	1,140	Dr	225	8	(?)	(?)	Brown sandstone	Ridgeley.....	20	?	A	125±	C,I	Reported draw-down 60 feet. Considerable water at 194 feet.
497	do.	Blair Ice & Cold Storage Co.	do.	1,110	Dr	504	8	(?)	(?)	Black soft shale	Shriver?.....	(?)	40	T	75	C,I	
498	Eldorado.....	R. A. Book.....	do.	1,090	Dr	180	8	(?)	(?)	Soft shale or sandstone	Onondaga or Ridgeley	(?)	3	P	30	I,Ir	
499	Catherine Township																Springs supply most of the homes in this vicinity.
500	Mount Etna.....	Mrs. E. M. Koontz..	do.	780	Dr	52±	6	(?)	(?)	Dolomite.....	Bellefonte....	(?)	12±	I	3-5	D	
501	1.7 miles northwest of Ganister	T. A. Lindsay.....	Ridge	1,290	Dr	106	6	NB	(?)	Yellow shale..	Clinton.....	106	85±	P	10	D	
502	1.6 miles north of Williamsburg	Russell Roller.....	Canyon	920	Dr	58	6	NB	(?)	Limestone....	Warrior.....	24	8	H	3-5	D,S	Considerable muddy water at depth of 85 feet
503	Williamsburg.....	West Virginia Pulp & Paper Co., Big Springs	Hillside	900	Sp					Dolomite.....	Gatesburg....			F	4,150±	I	
504	2.1 miles southwest of Williamsburg	James Bonsum.....	Slope	1,170	Dr	165	6	(?)	(?)	Limestone....	Warrior.....	(?)	?	P	5±	D,S	
505	0.5 mile west of Larke	T. D. Horton.....	Canyon	1,050	Dr	165±	6	(?)	(?)	Dolomite.....	Gatesburg....	(?)	10±	H,P	5±	D,S	Spring emerges along Williamsburg fault. Temperature 52°F. See analysis.
506	Rover.....	R. C. Hartman.....	Hillside	1,110	Sp					do.	Bellefonte....			F	250±	D	
507	do.	Miss Ida McAllister..	Canyon	1,100	Sp					do.	do.			F	1,500±	D,S	
508	Huston Township																Temperature 52°F. Many springs in vicinity. Water issues from four openings. Temperature 52°F. See p. 64 and pl. 17. Yield estimated.
509	Beavertown (Drab)	Levi Lininger.....	Hillside	1,180	DD	38	6	NB	(?)	do.	Nittany.....	38	?	H	3-5	D	
510	1.7 miles southwest of Beavertown	M. L. Acker.....	do.	1,260	Dr	120	6	NB	(?)	do.	do.	(?)	?	W,P	5±	D,S	

Typical wells and springs in Blair County—Continued

No. on pl. 2	Location	Owner or name	Topographic situation	Altitude (feet) ^a	Type of supply ^b	Depth (feet)	Diameter (inches)	Principal water-bearing bed				Length of casing (feet)	Depth to water level (feet)	Method of lift ^d	Yield (gallons a minute)	Use of water ^e	Remarks
								Depth to top of bed (feet) ^c	Thickness (feet)	Character of material	Geologic horizon						
509	Frankstown Twp. Flowing Spring station	Pennsylvania R. R., Flowing Spring	Valley	880	Sp	.....	.....	.....	.....	Limestone....	Tonoloway....	.....	.....	F	50-200±	D	Fibbing and flowing spring described on pp. 64-65. Temperature 50°F. See analysis.
510	0.3 mile northeast of Reese	H. D. Winter.....	Hillside	960	Dr	198	6	NB	(?)	Shale.....	Brallier.....	28	18±	P	6	D	Reported draw-down 40 feet.
511	Frankstown.....	M. S. Hunter.....	Valley	930	Dr	65	6	NB	(?)	do.	Hamilton.....	30±	?	I	3-5	D	
512	do.	James Curry.....	do.	930	Dr	95	6	NB	(?)	Blue slate....	Marcellus....	25	15±	P	3-5	D	
513	Blair Township Hollidaysburg.....	J. C. Lang.....	do.	990	Dr	184	6	NB	(?)	Limestone....	Clinton.....	15	12	P	30	Ir	Reported draw-down 142 feet.
514	do.	Thermic Coal & Coke Co.	do.	970	Dr	496	8	NB	(?)	Sandstone and shale	do.	40	48	A	386	C	Yield measured by engineer of ice plant. Temperature 54°F. See analysis.
515	0.6 mile east of Hollidaysburg	A. L. McIntyre.....	Slope	970	Dr	214	6	214	5-6	Channel in limestone	Shriver or Helderberg	134	40	P	5+	D	134 feet of mud, sand, and gravel, cased. Water level—48 feet in 1930. Supplies 4 families. Flows a small amount.
516	0.7 mile east of Hollidaysburg	Mrs. Priscilla Lyons	do.	960	Dr	120	6	(?)	(?)	Limestone....	Onondaga ± ..	(?)	+1-2	I	5±	D	Reported to flow about 3 gallons a minute in wet seasons. Reported draw-down 20 feet.
517	Loop.....	W. S. Van Zandt....	do.	960	Dr	50	6	(?)	(?)	Blue slate....	Marcellus....	25	±	I	10	D	
518	0.4 mile south of Duncansville	James Crane.....	Hillside	1,110	Dr	60	6	NB	(?)	Sandstone....	Ridgeley.....	30	30±	P	5	D	
519	Newry.....	T. G. Montgomery..	Valley	1,060	Dr	100	6	NB	(?)	Slate.....	Marcellus....	55	20±	P	9	D	
520	Allegheny Twp. Canaan.....	Altoona Packing Co..	do.	1,060	Dr	300	10	(?)	(?)	Dark slate....	Marcellus(?)..	30	?	?	2-3	N	Very small yield; abandoned.

521	Juniata Township 2.3 miles east of Summit	Prince Gallitzin Spring	Canyon	1,720	Sp							Sandstone.....	Pocono.....		F	5-10	D	On William Penn Highway. Temperature 50°F. See analysis.
522	2.2 miles west of Duncansville	C. O. Smith.....	do.	1,260	Dr	84	6	(?)	(?)			Shale or sandstone	Chemung.....	?	10-15	5 ±	D	See analysis.
523	do.	C. F. Holland.....	do.	1,260	Dr	25	6	(?)	(?)			Sandstone....	do.	20	3	15	D	
524	3.0 miles southwest of Duncansville	Bill Parks.....	Hillside	1,650	Dr	210	6	(?)	(?)			do.	do.	20	40 ±	5 ±	N	Pump not yet installed.
525	Freedom Township 0.5 mile north of East Freedom	Standard Oil Co.....	Valley	1,000	Dr	61	6	(?)	(?)			Sandstone or shale	Hamilton.....	21	2	5 ±	D	
526	Greenfield Township Claysburg.....	General Refractories Co., Weynant Spring	Hillside	1,180	Sp							Limestone....	Tonoloway.....			?	P	Reported large yield but never measured. Somewhat less yield during drought of 1930.
527	do.	Vernon Dibert.....	do.	1,200	Dr	53	6	NB	1.5			Channel in limestone	do.	32	6	9	D	Yield on bailing test without noticeable draw-down.
528	0.3 mile south of Sproul Taylor Township	General Refractories Co., Burket Stake Spring	do.	1,180	Sp							Limestone....	do.			100+	P	Yield estimated. Temperature 56°F. Chlorinated.
529	Roaring Spring....	D. M. Bare Paper Co., Roaring Spring	Canyon	1,200	Sp							Dolomite.....	Nittany.....			5,500 ±	P, I	Auxiliary public supply, printing office, paper mill, and flour mill. Yield measured in 1908, flow reported constant. Temperature 50°F. See analysis and pl. 16, A.
530	East Sharpsburg.	A. E. Stewart.....	Hillside	1,320	Dr	49	6	(?)	(?)			Limestone....	Lowville.....	?		1 ±	D	Pumps dry quickly in summer; larger yield in winter.
531	0.7 mile east of Roaring Spring	William Claar.....	Slope	1,380	Dr	91	6	NB	(?)			Crevice in dolomite	Bellefonte....	14	55	10 ±	D, S	
532	2.0 miles west of Martinsburg	Howard Burket.....	do.	1,410	Dr	89	6	89	1.5				do.	12	12	9	D, S	Reported draw-down 14 feet.
533	0.3 mile north of Ore Hill	Peter Duncan.....	do.	1,440	Dr	200	6	(?)	(?)			Dolomite.....	Mines.....	20	60 ±	8-10	D	
534	1.7 miles west of Curryville	D. M. Kensing.....	Valley	1,400	Dr	177	6	(?)	(?)			do.	Nittany.....	20	115 ±	7.5	D	

Typical wells and springs in Blair County—Continued

No. on pl. 2	Location	Owner or name	Topographic situation	Altitude (feet) ^a	Type of supply ^b	Depth (feet)	Diameter (inches)	Principal water-bearing bed			Length of casing (feet)	Depth to water level (feet)	Method of lift ^d	Yield (gallons a minute)	Use of water ^e	Remarks
								Depth to top of bed (feet) ^c	Thickness (feet)	Character of material						
535	North Woodbury Township	Irvin Stoner.....	Slope	1,420	Dr	180	6	177±	(?)	Channel in dolomite	12	50±	H,P	9	D,S	Reported draw-down 10 feet. Also uses cistern.
536	0.5 mile north of Martinsburg	T. C. Snowberger....	do.	1,320	Dr	66	6	66	(?)	do.	40	?	H	5±	D	
537	Clover Creek.....	N. Bridenbach.....	do.	1,450	Dr	117	6	NB	(?)	Dolomite.....	21	47±	P	10±	D,S	
538	1.4 miles southeast of Martinsburg	I. N. Keith.....	do.	1,440	Dr	221	6	221	(?)	Channel in dolomite	11	13	P	10±	D,S	Has a 157-foot well that yields very little. Use water softener for boiler. Reported draw-down 10 feet.
539	0.5 mile north of Curryville	Alhotts Dairies, Inc.	do.	1,440	Dr	147	6	135	(?)	do.	125	40	P	32	C,I	
540	0.2 miles northeast of Henrietta	A. L. Simmons.....	Hillside	1,410	Dr	63	6	(?)	(?)	Shale.....	42	20±	H	5±	D	

^a Altitudes taken from nearest contour on topographic maps unless otherwise indicated.^b Dr, drilled well; Du, dug well; DD, dug and drilled well; Sp, spring.^c NB, near bottom

^d A, air lift; F, natural flow; H, lift pump, hand-operated; I, pitcher pump, hand-operated; N, none;
^e P, force pump, power-operated; S, suction pump, power-operated; T, turbine pump, W, windmill.
^f C, condensing or cooling; D, domestic; I, industrial; Ir, irrigation; N, none; P, public supply; S, stock.
[†] Altitude by West Virginia Pulp & Paper Co., Tyrone.

Partial analyses of ground waters from Blair County

[Analyzed by E. W. Lohr. Parts per million. Numbers at heads of columns refer to corresponding numbers in the preceding table and on pl. 2.]

	468	489	493	502	509	514	521	522	529
Calcium (Ca).....	186	a 28	a 17	a 30	a 31	310	a 13	a 7	a 35
Magnesium (Mg).....	65	.....	.....	.....	.....	69	.....	.....	.....
Sodium and potassium (Na+K) (calculated).....	5.5	17	2	b	3	453	5	3	b
Bicarbonate (HCO ₃).....	199	155	61	154	164	163	40	16	174
Sulphate (SO ₄).....	523	a 32	a 12	a 3	13	141	a 7	20	10
Chloride (Cl).....	20	13	6.0	.6	1.0	1,250	2.0	3.0	1.0
Nitrate (NO ₃).....	9.4	.50	2.3	2.2	1.0	.....	3.7	7.7	8.1
Total dissolved solids (calculated).....	907	195	80	137	158	2,303	52	57	172
Total hardness as CaCO ₃	c 732	142	68	134	144	c 1,058	36	38	159
Date of collection (1933).....	Oct. 10	Oct. 10	Oct. 10	Oct. 10	Oct. 10	Oct. 11	Oct. 10	Oct. 11	Oct. 10

^a By turbidity.^b Less than 5.^c Calculated.

CAMBRIA COUNTY

Area 717 square miles. Population (1930) 203,146.

GEOGRAPHY

Cambria County ranks seventh in area but first in density of population among the counties covered by this report, with about 283 inhabitants to the square mile, as against 215 for the entire State. Johnstown, with 66,993 inhabitants in 1930, is the largest city in the county and the second largest in the area. There are 22 boroughs that have from 1,000 to more than 5,000 inhabitants. Coal mining and steel are the leading industries in this highly industrialized county, with Johnstown as the important steel city. The Federal census of 1929 credits the county with 158 manufacturing establishments whose annual products were valued at \$5,000 or more, of which 103 are in Johnstown (pl. 5, B). Only about 39 percent of the total land area is devoted to agriculture. The county is served by the main line and many branches of the Pennsylvania Railroad and is crossed by the William Penn Highway.

The topography is typical of the plateau province. Most of the county is high and rolling, but it is deeply dissected by the Conemaugh River in the vicinity of Johnstown (pl. 5, B). Cambria County is bordered on the east by Allegheny Mountain, which stands 2,860 feet above sea level in the southeast corner, the highest point in the county. Laurel Hill, which forms the southwestern border, has an altitude of 2,780 feet at one place. The Conemaugh River crosses the Westmoreland County line at an altitude of about 1,110 feet, the lowest point in the county. The maximum relief is therefore about 1,750 feet.

The Continental Divide traverses the northern part of the county along a northwest line connecting Nicktown, in Barr Township, and Summit, near Cresson, and thence south along the Allegheny Front. North and east of this line the water flows to the Atlantic chiefly down the West Branch of the Susquehanna River but in part down the Juniata River. The southern and larger part of the county drains into the Ohio through the Conemaugh River and its tributaries.

GEOLOGY

The rocks exposed in Cambria County are all Devonian and Carboniferous, ranging in ascending order from the Catskill formation, of Upper Devonian age, to the Monongahela formation, of Pennsylvanian age (pl. 1). There are no important unconsolidated deposits in the county, as the streams are still actively deepening their channels. The character and water-bearing

properties of the formations are given in the first half of this report.

The oldest rocks—the Catskill, Pocono, Loyalhanna, and Mauch Chunk formations—are exposed along the Allegheny Front and Laurel Hill. The Pottsville and Allegheny formations are exposed along the Allegheny Front and Laurel Hill and also in the deeper stream valleys in the northern and southwestern parts of the county. The Conemaugh formation occupies practically the whole county. A few thin remnants of the Monongahela formation occur in the southeastern part of the county.

The folds trend northeast. The Laurel Hill anticline forms the western border of the county, the east limb of the Nittany anticline forms the eastern border, and there is a succession of folds between.

GROUND WATER

The principal water-bearers in Cambria County are the sandstones of the Pottsville, Allegheny, and Conemaugh formations. Owing to its great areal extent, the Conemaugh supplies most of the wells in the county, including some of the industrial and public-supply wells and most of the domestic wells. Most of the industries and larger towns are situated in the valleys, however, where the wells tap the Allegheny and Pottsville and, in a few places, rocks underlying the Pottsville.

Ground water in Cambria County is recovered principally by means of drilled wells. A few dug wells were observed, chiefly in the northeastern part of the county. Small hillside springs are numerous, some of which are used for public supply, but no large springs were observed. Ground water is recovered from mine shafts by some of the coal companies (nos. 410, 454, and p. 66), and the borough of Hastings is supplied by an abandoned mine drainage tunnel used as an infiltration gallery (no. 392 and p. 65). Well 460, which may be called an inverted well, is unique in that water is withdrawn through the bottom instead of through the top (p. 59 and fig. 11).

Wells in some parts of the county have been drained or spoiled by nearby coal mining, and some of them by actual undermining. An example is found in the hilly region around Geistown, Richland Township, where most of the wells were dried up. The coal companies responsible for this result have supplied the people with running water piped from Windber.

Most of the ground-water developments are domestic, but the largest developments are for public supply, and secondly for industrial supply. The principal industrial use is condensing or

cooling by dairies and ice companies, but some is used for boiler feed by coal companies. The Bethlehem Steel Corporation obtains its large industrial water supply from the Quemahoning reservoir, in Somerset County. Most of the water used for boiler feed is believed to be purchased from municipalities.

Only three flowing wells were noted in Cambria County (nos. 395, 421, 429), but it is possible that others may be obtained in the several synclinal basins that traverse the county.

The analyses of 8 samples of ground water from Cambria County are given below. Most of the ground waters from the Conemaugh are only moderately mineralized and moderately hard and appear to be the best ground waters in the county. Iron in objectionable amounts occurs in some waters from the Allegheny formation and will probably be found in most waters from the Pottsville and Mauch Chunk. Only one of the samples (no. 447) contains a large amount of iron, but iron was reported in many other well waters. Analyses 389, 392, and 447 indicate very hard waters containing large amounts of sulphate. Several wells in Cambria County, including wells 402, 403, 405, and a well at the brewery in South Fork, have been abandoned because of the poor quality of water obtained. The occurrence of ground water in and near coal mines and the quality of water to be expected from the different geologic formations is summarized in the first part of this report. pp. 80, 81.)

PUBLIC SUPPLIES

The city of Johnstown, most of the larger boroughs, and some of the smaller places in Cambria County are supplied by surface water, including Amsbry, Bakerton, Blandburg, Cassandra, Cresson (in part), Expidit, Irwin, Gallitzin, Lilly, Patton, Portage, South Fork, parts of Summerhill Township, Vintondale, Wilmore, all the communities near Johnstown, and perhaps others. Records are given below of 12 public supplies derived exclusively from ground water and of 7 derived from ground and surface water.

Barnesboro (population 3,506) is supplied from one drilled well (no. 389) by the Barnesboro Water Co. There is another well of similar depth that is not needed except in emergencies. The turbine pump on the well discharges at the rate of 150 gallons a minute into an 8,000-gallon wooden tank near the well, from which the water is pumped by one of two centrifugal booster pumps having a capacity of 200 and 300 gallons a minute to the main reservoir, whence it is distributed by gravity. The reservoir is of the open concrete type, holds 500,000 gallons, and is located on a hill west of the borough. Pressures in different

parts of the borough range from 85 to 112 pounds to the square inch. The daily consumption averages about 220,000 gallons, most of which is used by the inhabitants, but a small part is used by one shirt factory. There are 35 fire hydrants in the system. As shown by analysis 389, the water is very hard but is served without treatment of any kind.

Carrolltown (population 1,227) is supplied with ground water by the Carrolltown Water Co. from wells and a spring 0.8 mile southeast of the center of the borough. During periods of normal rainfall the supply is obtained entirely from a spring (no. 397). There are three drilled wells for emergency use, two of which (nos. 399 and 400) yield but little water and are seldom used. The other well (no. 398, see log) yields about 30 gallons a minute. The wells are pumped by steam plunger pumps and discharge into the spring basin, from which water is pumped by a steam booster pump at a rate of 150 gallons a minute to the reservoir, 260 feet higher, whence it is distributed by gravity. The reservoir is constructed of brick and concrete, is covered, holds 92,000 gallons, and is situated on a hill west of the borough, at an altitude of about 2,220 feet. Pressures in different parts of the borough range from 10 to 25 pounds to the square inch. The daily consumption averages about 60,000 gallons, none of which is used by any industry. There are 21 fire hydrants in the system. The water does not require treatment of any kind and is of good quality, as shown by analysis 398.

Colver (population about 1,200) is supplied with ground and surface water by the Colver Water Co., a subsidiary of the Ebensburg Coal Co. The four drilled wells (nos. 418-421), pumping plant, and impounding dam are at Vetera, which is 1½ miles northeast of Colver and 200 feet lower. The dam impounds 25,000,000 gallons, and the small streams furnish all the water needed except during the summer. One well flows, two wells are pumped by air lift, and the other by turbine pump. Water from the wells or reservoir is pumped by a booster pump with a capacity of 450 gallons a minute to the reservoir in Colver, whence it is distributed by gravity. The distributing reservoir, which is made of brick and is not covered, holds 1,000,000 gallons. Water pressures in different parts of Colver range from 10 or 15 to 125 pounds to the square inch. The daily consumption averages about 270,000 gallons, 40 percent of which is used by the power house that operates the mines. There are 30 fire hydrants in the system. The water is treated with chlorine gas. The log of well 420 and an analysis of water from this well are given below. An unsuc-

cessful attempt was made to develop a ground-water supply at Colver. (See well 405, log.)

The State Tuberculosis Sanatorium, on Allegheny Mountain southeast of Cresson, is supplied by 9 small springs (no. 433), with an aggregate yield of 12 to 80 gallons a minute. The water is collected in a small basin and pumped a vertical distance of about 150 feet to a distributing reservoir at the sanatorium. About 1,000 people are served, and during the summer some water is purchased from the Summit Water Co. A deep drilled well at the pumping plant is reported to have been spoiled by coal mining. The spring water is reported to be very soft and low in dissolved mineral matter.

Ebensburg, the county seat (population 3,063), is supplied by the Ebensburg Borough Water Co. The main supply comes from small streams northeast of the borough which flow into a 30,000-000-gallon reservoir. In dry weather the supply is augmented by water from two drilled wells near the dam (nos. 422 and 423). The water is treated with lime, soda ash, and chlorine gas and is pumped to two brick and concrete reservoirs in the borough having a total capacity of 630,000 gallons, from which it is distributed by gravity. Water pressures in different parts of the borough range from 15 or 20 to 55 pounds to the square inch. The average daily consumption is about 300,000 gallons, none of which is used for manufacturing. The Ebensburg Borough Water Co. also supplies the Cambria County Home. The water from the wells is of good quality, as shown by analysis 423.

Hastings (population 2,011) is supplied with ground water by the Hastings Borough Water Co. The water is obtained from an abandoned mine drainage tunnel on a hill 1.7 miles southeast of the borough, which is used as an infiltration gallery (no. 392). The water flows into a 16,000-gallon collecting reservoir and thence to two concrete reservoirs, each holding 90,000 gallons, from which it is distributed by gravity. The average pressure in the borough is about 90 pounds to the square inch. The average daily consumption in 1929 was 165,000 gallons. There are 24 fire hydrants in the system. The water is chlorinated. As shown by analysis 392, the water is very hard.

Water is supplied free of charge to the borough of Loretto (population 352) by Charles M. Schwab, whose estate adjoins the borough. The water is obtained from one drilled well (no. 426) and is pumped to a stone reservoir with a capacity of 1,500-000 gallons, whence it is distributed by gravity. Pressures in Loretto range from 50 to 80 pounds to the square inch. The

average daily consumption is about 27,000 gallons, none of which is used for manufacturing. The water is reported to be hard but is not treated. There are two other drilled wells (nos. 427 and 428) that supply the Schwab estate.

Marsteller (Moss Creek) is supplied with water from well 404 (see log) by the Henrietta Water Co., a subsidiary of the Cambria County Water Supply Co. The water is pumped to two reservoirs, one made of concrete, the other of wood, and is distributed by gravity. About 900 people are served. The water is reported to be of good quality and is not treated.

Nanty Glo (population 5,598) is supplied by the Nanty Glo Borough Water Co. The main supply comes from two small streams, but in dry seasons one drilled well is also used (no. 409; see log). The dam impounds about 500,000 gallons, and the water is distributed by gravity. When the well is used, the water is pumped into the mains. Pressures in the borough range from 15 to 85 pounds to the square inch. The average daily consumption is about 100,000 gallons. There are 30 fire hydrants in the system. The water is not treated. Several nearby mining villages are supplied by springs and small streams, and one comprising 54 homes is supplied from well 438 by the Senwick Water Co. The water from this well is pumped to a 20,000-gallon tank at an altitude of 1,981 feet and is distributed by gravity.

The mining village of Revloc is supplied by the Monroe Coal Co. with water from a small stream and from water rings in a mine shaft (no. 410). The average daily consumption is about 70,500 gallons.

About 120 homes in St. Benedict are supplied by Peal, Peacock & Kerr from spring 401. The water is distributed by gravity from a 36,000-gallon reservoir and is not treated.

The mining village of St. Michael is supplied by the Berwind-White Coal Co. from water rings in a mine shaft (no. 454; see log). The water is pumped at the rate of 325 gallons a minute into a 100,000-gallon tank and is distributed by gravity. Most of the water is used by the boiler house and the mine, and the remainder supplies about 150 families.

About 12 families in Salix are supplied from well 456 by the Salix Mutual Water Co., and another group of homes is supplied from a dug well and several small springs owned by a Mr. Felix.

Sankertown (population 917), which adjoins Cresson, is furnished with water by the borough. In the winter a small spring furnishes all the water needed, but in the summer 80 percent of the supply comes from a small stream. The stream water is pur-

chased in a treated condition, but the spring water does not require treatment. The spring and stream flow by gravity into a 250,000-gallon open reservoir in the lower part of the borough, from which the water is pumped directly into the mains at a pressure of 40 to 55 pounds to the square inch. There are 15 fire hydrants in the system.

Part of Sidman is supplied from two springs and one drilled well (no. 455) owned by S. R. Miller, and the remainder is supplied with surface water by the Summit Water Supply Co. In wet seasons the two springs supply all the water needed, but during several years after the drought of 1930 the well was required a large part of the time. The water from the springs and discharge pipe of the well flows into two concrete reservoirs holding 84,000 and 10,800 gallons, and is distributed by gravity. The average pressure is 35 to 40 pounds to the square inch. The average daily consumption is about 1,500 gallons. The water does not require treatment. The water from the drilled well is of good quality, as shown by analysis 455.

Spangler (population 2,761) is supplied by the Northern Cambria Water Co. Prior to 1934 the supply came entirely from streams, but in that year a drilled well (no. 391; see log) was completed and is now available as an emergency source during dry weather. Two reservoirs hold a total of 44,000,000 gallons. One reservoir receives stream water by gravity, but water is pumped over a hill to the other reservoir. The stream water is distributed by gravity, and the well water, after chlorination, is pumped directly into the mains. Pressures in different parts of the borough range from 50 to 86 pounds to the square inch. The inhabitants use an average of about 450,000 gallons a day, and in addition about 25,000 gallons a day is sold to the Pennsylvania Railroad. There are 17 fire hydrants in the system. The stream water is treated, but the well water is reported to be of good quality and probably will not require treatment.

Summerhill (population 785) and Ehrenfeld are supplied by the Forest Water Co., a subsidiary of the Cambria County Water Supply Co. Prior to 1933 the supply came entirely from a small stream, but in that year a drilled well (no. 436) was put down. Owing to the large yield and good quality of water obtained from the well, it now constitutes the main supply, and the stream will be used in emergencies. The water from the well and stream flows into a 120,000-gallon reservoir, whence it is distributed by gravity. Another reservoir holding 85,000 gallons is held in reserve. Water is furnished to 1,600 to 1,800 people.

Typical wells and springs in Cambria County

No. on pl. 2	Location	Owner or name	Topographic situation	Altitude (feet) ^a	Type of supply ^b	Depth (feet)	Diameter (inches)	Principal water-bearing bed				Length of casing (feet)	Depth to water level (feet)	Method of lift ^c	Yield (gallons a minute)	Use of water ^f	Remarks
								Depth to top of bed (feet) ^e	Thickness (feet)	Character of material ^d	Geological horizon						
389	Susquehanna Twp. Barnesboro.....	Barnesboro Water Co.	Valley	1,420	Dr	120	8	NB	(?)	Sandy sh. or sandstone	Kittanning ss.	80	16	T	150	P	Has a similar well that is not needed. Reported draw-down of 61 feet. Temperature 52°F. See analysis.
390	Spangler.....	W. E. Hoffman Dairy	do.	1,460	Dr	290±	6	do.	(?)	Dark sandy shale	Homewood sandstone±	190±	25	T	90	C	Water reported to be hard and to contain con- siderable iron.
391	do.	Northern Cambria Water Co.	do.	1,470±	Dr	362	12-8	234 297	36 65	Gray ss. Light ss.	Pottsville..... Pottsville or Man. Chunk	200	46	T	250	P	Reported draw-down 96 feet after pumping 4 days. Casing surrounded by cement layer 2 inches thick. No excess iron reported. See log.
392	Elder Township 1.7 miles southwest of Hastings	Hastings Borough Water Co.	Hillside	2,000±	IG	.....	.....	.....	.....	Coal.....	Upper Free- port coal?	.....	.....	F	100- 300	P	Abandoned mine drainage tunnel used as an in- filtration gallery. Tem- perature 51°F. See analysis.
393	0.6 mile west of St. Lawrence	Lewis Lechene.....	Hilltop	2,200	Dr	75	6	55	20	Hard black slate	Lower Cone- maugh	15	20±	H	2-5	D	Supplies fire tower.
394	St. Lawrence..... Dean Township	George Wamer.....	do.	2,160	DD	75	6	NB	(?)	Slate.....	do.	24	45±	H	2-5	D	
395	Asheville.....	Mrs. A. R. Burgoon...	Hillside	1,660	Dr	66	(?)	(?)	(?)	(?)	Middle Allegheny	(?)	+1 or 2	F	3-4	D	Other drilled wells in Ashe- ville reported nonflow- ing. Temperature 51°F.
396	Clearfield Township St. Augustine.....	D. F. Horne.....	Ridge	1,650	Dr	116	6	(?)	(?)	(?)	Saltsburg sandstone±	(?)	50±	P	3-4	D,S	Pumps dry in 4 hours at 5 gallons a minute. Farms in nearby valleys use springs, those on hills use dug wells.

East Carroll Twp.	Carrolltown Water Co.	Valley	1,960	Sp	.....	.....	.....	.....	Sandstone and shale	Mahoning sandstone	.....	F	0-70	P	Reported to yield 60,000 to 100,000 gallons a day in wet months; not flowing on Aug. 16, 1933. Walled and covered. Temperature 52°F. See analysis. No coal encountered, see log.
397 0.8 mile southeast of Carrolltown	do.	do.	1,960	Dr	208	10-8	180	28	Dark slate..	Below Upper Kittanning	47	P	30	P	Walled and covered. Temperature 52°F. See analysis. No coal encountered, see log.
398 do.	do.	do.	1,960	Dr	95	6	(?)	(?)	Shale.....	Butler sandstone	(?)	P	(?)	P	Small yield, seldom used. No coal encountered.
399 do.	do.	do.	1,960	Dr	145	6	(?)	(?)	do.	Freeport ss....	(?)	P	(?)	P	Do.
400 do.	do.	do.	1,960	Dr	145	6	(?)	(?)	do.	Freeport ss....	(?)	P	(?)	P	Do.
West Carroll Twp.	Mr. Hartbrook.....	Canyon	1,900	Sp	.....	.....	.....	.....	(?)	Upper Kittanning coal±	.....	F	(?)	P	Small yield in summer. Water reported to be hard and to contain excess iron.
401 0.5 mile east of St. Benedict	do.	do.	1,900	Sp	.....	.....	.....	.....	(?)	Upper Kittanning coal±	.....	F	(?)	P	Small yield in summer. Water reported to be hard and to contain excess iron.
402 1.0 mile south of Spangler	New York Central R. R.	Valley	1,550	Dr	150	6	135	12	Sandstone	Homewood ss.	126	P	40±	N	Intended for locomotive boiler use, but water reported to be hard and to contain excess iron.
403 1.2 miles northwest of Bakerton	Barnes Coal Co.,....	do.	1,540	Dr	174	?	80±	94±	Ss. (?).....	Pottsville.....	80±	N	(?)	N	Good supply of good water eased off between Brookville and Lower Kittanning coals. Large supply in Pottsville, but water reported to be unfit to drink.
Barr Township															
404 0.2 mile south of Marsteller	Cambria County Water Supply Co. (Henrietta Water Co.)	Hillside	1,550	Dr	158.5	12-8	140	18.5	Sandstone..	Below Upper Kittanning coal	(?)	P	50	P	Water reported to be of good quality. See log.
405 0.4 mile southeast of Colver	Ebensburg Coal Co.,..	do.	1,800	Dr	541	10-6	531	10	Soft white sandstone	Connoquenesing or Mau. Chunk	(?)	N	(?)	N	Salt water reported at bottom, better (?) water at 190 feet. See log.
Blacklick Township															
406 1.5 miles west of Belsano	Ben Franklin Inn....	do.	1,660	Dr	73	6	63	10	Slate.....	Buffalo ss.	18.3	H	1+	D	Broken sandstone overlies slate.
407 0.7 mile north of Belsano	Mrs. Heming.....	do.	1,730	Dr	60	6	50	10	Soft ss.	Buffalo ss.	20.5	H	8	D	Sandstone underlies 18 feet of clay. Yield measured by driller in fall of 1932.

Typical wells and springs in Cambria County—Continued

No. on pl. 2	Location	Owner or name	Topographic situation	Altitude (feet) ^a	Type of supply ^b	Depth (feet)	Diameter (inches)	Principal water-bearing bed				Length of casing (feet)	Depth to water level (feet)	Method of lift ^c	Yield (gallons a minute)	Use of water ^d	Remarks	
								Depth to top of bed (feet) ^e	Thickness (feet)	Character of material ^f	Hard ss. . . .							Connoquenes- sing ss. . . .
408	1 mile north of Nanty Glo	Stanley Nipps.	Valley	1,840	Dr	271	6	NB	(?)	(?)			45	103	H	3	D	Cased through Brookville coal. Yield measured by driller in fall of 1932. Water reported to contain excess iron.
409	Nanty Glo.	Nanty Glo Borough Water Co.	do.	1,680	Dr	190	10	152	37	Sandstone. . .		do.	113	20	A	280	P	Reported draw-down 70 feet after 2 days' pumping. Water reported to contain excess iron. Water level measured 1930. See log.
410	Cambria Township Revloc.	Monroe Coal Co.	do.	1,900	MS	150+	?			?		Upper Allegheny and Lower Conemaugh		(?)	(?)	25	P	Water ring at depth of 90 feet collects more water than ring at 150 feet. Well nearly 94 feet deep reported dry.
411	0.8 mile west of Ebensburg	Seth Stevens.	Canyon	1,920	Dr	60	6	NB	(?)	Slate.		Lower Conemaugh	23	(?)	H	?	D	Water reported to be of good quality. Nearby wells reported to yield iron-bearing water.
412	2.0 miles southeast of Colver	J. Stanko.	Hillside	2,300	Dr	63.5	6	20	43.5	Sandstone. . .		Buffalo ss. = . .	(?)	(?)	(?)	35±	D	Water reported to contain excess iron.
413	Tripolo.	T. L. Altemus.	do.	2,300	Dr	75	6	(?)	(?)	(?)		Buffalo ss. . . .	(?)	48	P	5	D	Yield estimated Aug. 17, 1933; reported to yield 40 gallons a minute in wet weather. Water is of good quality. Temperature 54°F.
414	1.8 miles east of Colver	Ebensburg Coal Co. . .	do.	2,200	Sp					Sandstone. . .		do.			F	2-3	D	Water reported to be iron-bearing. Crevice at depth of 162 feet took all water above. Colver is undetermined.
415	do.	do.	do.	2,200	Dr	99	6	91	4	do.		Mahoning ss. . .	(?)	(?)	H	3	N	
416	0.7 mile southeast of Colver	Cambria & Indiana R. R.	Canyon	1,840	Dr	181	?	53	12	Shale.		Freepport ss. . .	(?)	162±	N	?	N	

417	2.2 miles east of Colver	Bob Lute.....	Ridge	2,150	Dr	100	6	NB	(?)	(?)	(?)	Lower Cone-naugh Butler ss.....	(?)	H	½	D	Wells 418, 419, 420, and 421 are close together.
418	Vetere.....	Colver Water Co. (Ebensburg Coal Co.)	Valley	1,814*	Dr	131	8	85	27	Sandstone..	(?)	do.	(?)	T	75-100	P	Temperature 49°F. See analysis and log.
419	do.	do.	do.	1,800*	Dr	87	8	71	13	do.	(?)	do.	(?)	A	93	P	Flows a small amount.
420	do.	do.	do.	1,805*	Dr	101	8	75	20	do.	(?)	do.	(?)	A	72	P	Draw-down 4 or 5 feet. Some water at depth of 55 feet. Most water in crevice 10 feet above bottom.
421	do.	do.	do.	1,802*	Dr	80	8	55	18±	do.	(?)	do.	(?)	N(F)	50	N	Draw-down 4 or 5 feet. Some water at depth of 55 feet. Most water in crevice 10 feet above bottom.
422	Ebensburg.....	Ebensburg Borough Water Co.	Hillside	2,000	Dr	133	8	104	29	do.	55	Buffalo ss.....	45±	T	100	P	About 300 feet east of no. 422. Draw-down 4 or 5 feet. Some water at depth of 38 feet. See analysis. Temperature 49°F.
423	do.	do.	Valley	1,980	Dr	100	8	67	33	do.	41	do.	45±	T	125	P	Numerous small springs in vicinity.
Allegheny Township																	
424	Chest Springs.....	C. W. Little.....	Hillside	1,980	Dr	62	6	(?)	(?)	(?)	(?)	Upper Cone-naugh do.	20±	H	2-3	D	Reported nearly dry in 1930.
425	0.4 mile west of Loreto	Carmelite Monastery	Ridge	2,080	Dr	124	6	NB	(?)	Slate.....	18	do.	50±	P	25	D	Draw-down 10 or 12 feet. Used 6 hours a day. Water reported to be hard and to contain excess iron.
426	0.8 mile east of Loreto	Charles M. Schwab..	Valley	1,800	Dr	151	10	(?)	(?)	(?)	33	Morgantown ss.±	8±	T	75	P	Uses zeolite softener. Smaller yield because pump forces water uphill. Supplies estate. Auxiliary supply for estate.
427	do.	do.	do.	1,800	Dr	175	10	(?)	(?)	(?)	30	do.	8±	T	50	D	Redrilled 2½-inch diamond-drill hole. Supplies Cressoreto Tavern. Flows 15 gallons a minute. Temperature 48°F. See analysis.
428	do.	do.	do.	1,800	Dr	37	(?)	(?)	(?)	(?)	14	Upper Cone-naugh	8±	T	30	D	
429	Cresson Township	Lee Hoffman.....	do.	1,800	Dr	125	8	(?)	(?)	(?)	40±+15±	Buffalo ss.....	25+	F,S		D	
430	1.7 miles northwest of Cresson	Mary Conway.....	Hillside	2,080	Dr	80	6	70	10	Sandstone..	21	do.	20±	H	3	D	

*Altitudes from Ebensburg Coal Co.

Typical wells and springs in Cambria County—Continued

No. on pl. 2	Location	Owner or name	Topographic situation	Altitude (feet) ^a	Type of supply ^b	Depth (feet)	Diameter (inches)	Principal water-bearing bed				Length of casing (feet)	Depth to water level (feet)	Method of lift ^c	Yield (gallons a minute)	Use of water ^f	Remarks
								Depth to top of bed (feet) ^e	Thickness (feet)	Character of material ^d	Geologic horizon						
431	Cresson Township 1 mile east of Summit	J. C. Weston.....	Hilltop	2,320	Dr	130	6	120	0.1±	Crevice in green sh.	Upper Kittan- ning coal±	61.7	90	N	8±	N	Cased through Upper Free- port coal. Casing rusted through in about 2 years.
432	0.5 mile east of Summit	R. R. Jones.....	do.	2,420	Dr	384	6	384—	(?)	(?)	Lower Allegheny	210	334±	N	1—	N	Aggregate yield 12 gallons a minute in dry season; 80 in wet seasons. Deep well at pumping plant reported spoiled by coal mining.
433	0.3 mile south of Summit	Cresson State Sani- torium	Hillside	2,300±	9 Sp	.....	.....	.....	(?)	(?)	Lower Conemaugh	.....	.....	F	12 to 80	H	
434	1 mile northeast of Lilly	Bill Delozier.....	do.	2,110	Dr	73	6	NB	(?)	Shale.....	Lower Free- port coal±	30	?	H	1-3	D	
435	Washington Twp. 0.3 mile south of Lilly	John McNally.....	Valley	1,870	Dr	78	6	NB	(?)	Shale?.....	Below Upper Freeport coal	46	?	N	?	N	Reported acid water unfit for use.
436	Croyle Township 1 mile northeast of Summerhill	Cambria County Water Supply Co. (Forest Water Co.)	Canyon	1,720	Dr	175	10	175—	(?)	Sandstone?	Buffalo ss....	(?)	54	T	250	P	Draw-down 15 feet after pumping 45 minutes. Water reported to be of good quality.
437	South Fork.....	Mr. Shultzberger...	Hillside	1,560	Dr	115	6	95	20	Slate.....	Pottsville.....	44	35±	H	3-5	D	Well at brewery aban- doned because water contained excess iron.
438	Jackson Township 0.6 mile west of Nanty Glo	Senwick Water Co...	do.	†1,904	Dr	253	8 or 10	(?)	(?)	Sandstone?	Connoquenes- sing ss.	(?)	?	P	?	P	Supplies 54 houses.

439	do.	do.	do.	1,904†	Dr	473.5	8 or 10	(?)	(?)	?	Mauch Chunk or Pocono	(?)	?	N	?	N	Drilling this well increased yield of well 438, 50 feet away; therefore it is not pumped.
440	0.3 mile west of Dearmin	P. J. Roper.....	Ridge	2,020	Dr	75	8	60	15	Slate.....	Buffalo ss. ±	14	10±	H	40	D	20 feet of sandstone above slate not water-bearing. Driller reported 15-foot draw-down during test. Water reported to con- tain excess iron. Good water reported.
441	Mundy's Corner...	R. J. Adams.....	Hillside	1,900	Dr	75	6	60	15	do.	do.	7	25±	P	5+	D	
442	Fairview (Vinc post office)	T. Gillen.....	do.	1,730	Dr	60	6	52	8	do.	Morgantown sandstone ±	18	?	H	10±	D	
443	East Taylor Twp.																
443	0.8 mile west of Mineral Point	Mrs. Custer.....	do.	1,540	Dr	100	6	85	15	do.	Middle Kittan- ning coal ±	18	50±	H	1 ±	D	Slate overlain by fire clay.
444	Lower Yoder Twp.																
444	0.7 mile west of Johnstown	Friendly City Loan Co.	do.	1,680±	Dr	68	6	60	8	do.	Lower Conemaugh	15	30±	P	3	D	
445	Upper Yoder Twp.																
445	0.5 mile southwest of Ferndale	Millers Dairy.....	do.	1,350	Du	38	14	(?)	(?)	?	Mahoning ss.	38	29	P	3-5	C	
446	City of Johnstown																
446	Morrellville.....	Ralph Walst.....	do.	1,280	DD	78	6	71.5	6.5	Slate.....	Homewood ss.	25	?	H	3-5	Ir	Used for garden. Water reported to contain ex- cess iron. Some water in coal at 55 feet. No coal reported. Slate overlain by 115 feet of red shale. Draw-down 71 feet. Temperature 53°F. Water contains excess iron. See analysis.
447	Johnstown.....	Johnstown Sanitary Dairy Co.	Valley	1,160	Dr	363	10	362	1+	do.	Mauch Chunk (?)	160	26	T	180	C	
448	do.	Schaffer Ice Co.....	do.	1,180	Dr	206	8	NB	(?)	Sandstone..	Connoquenes- sing ss.	170	50	A	100 ±	C	
449	Conemaugh Twp. Parktown.....	E. L. Williams.....	Hillside	1,820	Dr	155	6	100	45	Slate.....	Below Salts- burg ss.	20	100±	H	3-5	D	See log.
450	0.8 mile northeast of Walnut Grove	B. F. Heckler.....	Hilltop	1,920	Dr	160	6	75 155	10 5	Sandstone.. Slate.....	do. Mahoning ss.	25	25 ±	P	5-10	D	Drilled 375 feet for coal test; plugged at depth of 100 feet above minel- out coal (Upper Free- port). See log.

† Altitudes from Monroe Coal Co.

Typical wells and springs in Cambria County—Continued

No. on pl. 2	Location	Owner or name	Topographic situation	Altitude (feet) ^a	Type of supply ^b	Depth (feet)	Diameter (inches)	Principal water-bearing bed				Length of casing (feet)	Depth to water level (feet)	Method of lift ^c	Yield (gallons a minute)	Use of water ^d	Remarks
								Depth to top of bed (feet) ^e	Thickness (feet)	Character of material ^d	Geologic horizon						
451	Richland Township 1.8 miles east of Walnut Grove	Sheesley Supply Co.	Canyon	1,720	Dr	53	6	NB	(?)	Slate.....	Above Lower Kittanning coal	8	10±	P	3-4	I	Used for washing coal.
452	0.7 mile south of Geistown	Guy Gennetti.....	Hillside	2,040	Dr	91	6	NB	(?)	do.	Above Mahon- ing ss.	10	45±	P	5-6	D	Many wells in Geistown ruined from under- mining.
453	2 miles southeast of Geistown	Superior Inn.....	do.	2,240	Dr	70	8	60	10	do.	Buffalo ss.±..	23	25±	P	4+	D	Slate below hard sand- stone.
454	Adams Township 0.2 mile south of St. Michael	Berwind-White Coal Co.	Valley	± 1,604	MS	260	.....	.....	260	Sandstone, slate, and coal	Middle Conemaugh	907	?	P or T	325+	I, P	Shaft 907 feet deep, water rings at depths of 112, 198, and 260 feet, most water from lower two. Maximum yield about 1,800 gallons a minute. See log.
455	0.3 mile southwest of Sidman (Lovett)	S. R. Miller.....	Hillside	1,700	Dr	285	8	NB	(?)	Sandstone..	Buffalo ss. . . .	20	50±	P	32	P	Formerly 185 feet deep with small yield. Draw- down 50 feet. Tempera- ture 51°F. See analysis. Supplies 12 houses. Water reported to be good.
456	Salix.....	Salix Mutual Water Co.	Hilltop	2,080	Dr	93	6	73	(?)	Crevice in sandstone	Morgantown sandstone	(?)	73	W	4-5	P	
457	1.1 miles southwest of Salix	George Marsh.....	Hillside	2,120	Dr	85	6	NB	(?)	Soft shale...	Above Mor- gantown ss.	20	?	H	?	D	
458	0.8 mile north of Elton	Mr. Miller.....	do.	2,150	Dr	121	6	NB	(?)	Slate.....	do.	22	70±	H	5±	D	Formerly 74 feet deep but went dry, presumably from undermining of coal.
459	Elton.....	S. L. Horner.....	do.	2,100	Dr	60	6	45	15	do.	Morgantown sandstone	12	15	H	5±	D	

460	1 mile south of Salix	Berwind-White Coal Co.	do.	±2,150	Dr	632	8	235	(?)	Crevice in sandstone	Buffalo sandstone	632	40	F	20	C	Inverted well; see p. 59 and fig. 11. 3-inch slotted casing with gravel pack, lower 330 feet cemented. Water drains out at bottom to compressor in mine tun- nel. Some water in crevice at depth of 100 feet. Supplies fire tower; loca- tion not checked.
461	2 miles southeast of Llanfair	Pennsylvania Dept. Forests and Waters	Hilltop	2,750	Dr	92	6	NB	(?)	Black slate	Morgantown sandstone	8	65±	H	1-3	D	

^a Altitudes taken from nearest contour on topographic maps unless otherwise indicated.

^b Dr, drilled well; Du, dug well; DD, dug and drilled well; IG, infiltration gallery; MS, mine shaft equipped with water rings; Sp, spring.

^c NB, near bottom.

^d Sb, shale; ss, sandstone.

^e A, air lift; F, natural flow; H, lift pump, hand-operated; N, none; P, force pump, power-operated;

^f S, suction pump, power-operated; T, turbine pump; W, windmill.

[†] C, condensing or cooling; D, domestic; I, industrial; Ir, irrigation; N, none; P, public supply; S, Stock.

‡ Altitudes from Berwind-White Coal Co.

Partial analyses of ground waters from Cambria County

[Analyzed by E. W. Lohr. Parts per million. Numbers at heads of columns refer to corresponding numbers in the preceding table and on pl. 2.]

	389	392	398	420	423	429	447	455
Iron (Fe).....							26	.....
Calcium (Ca).....	87	236	38	a 30	a 40	a 26	72	a 28
Magnesium (Mg).....	21	64					21	.....
Sodium and potassium (Na+K) (calculated).....	30	b	3	b	5	27	125	2
Bicarbonate (HCO ₃).....	163	222	114	101	126	187	138	113
Sulphate (SO ₄).....	210	630	a 8	13	10	a 7	313	60
Chloride (Cl).....	12	2.0	2.0	1.0	3.0	1.0	70	2.0
Nitrate (NO ₃).....	.0	.20	.40	.30	.10	.0	.10	.10
Total dissolved solids (calculated).....	440	1,042	110	104	124	167	669	182
Total hardness as CaCO ₃	c 304	c 852	98	96	108	104	266	153
Date of collection (1933).....	Oct. 11	Oct. 11	Oct. 11	Oct. 11	Oct. 11	Oct. 10	Oct. 11	Oct. 11

^a By turbidity.

^b Less than 5.

^c Calculated.

WELL LOGS

North Cambria Water Co., at Spangler

[No. 391. Authority, Hoffman Bros., drillers]

	Thick- ness (feet)	Depth (feet)		Thick- ness (feet)	Depth (feet)
Surface material.....	62	62	Sandstone, light.....	27	126
Shale, dark.....	3	65	Sandstone, dark.....	3	129
Coal.....	5	65.5	Sandstone, gray.....	76	205
Shale, dark.....	2.5	68	Shale, dark.....	20	225
Sandstone, gray.....	2	70	Shale, gray.....	9	234
Shale, dark.....	10	80	Sandstone, gray.....	36	270
Shale, dark with coal streaks...	8	88	Shale, gray.....	27	297
Shale, gray.....	11	99	Sandstone, light.....	65	362

Carrolltown Water Co., near Carrolltown

[No. 398. Authority, Hoffman Bros., drillers]

Soil and decomposed rock.....	21	21	Shale, dark, clay.....	24	117
Sandstone.....	12	33	Shale, dark.....	8	125
Clay.....	8	41	Shale, gray.....	55	180
Shale, "lime".....	20	61	Slate, dark (water-bearing)...	28	208
Shale, gray.....	32	93			

Cambria County Water Supply Co., near Marsteller (Moss Creek)

[No. 404. Authority, Hoffman Bros., drillers]

Soil and decomposed rock.....	50	50	Shale, dark.....	6	104
Slate, black.....	17	67	Slate, black.....	20	124
Coal (Lower Freeport, D).....	1	68	Coal (Upper Kittanning, C')..	3	127
Shale, sandy.....	10	78	Fire clay.....	6	133
Slate, dark.....	7	85	Shale, sandy.....	7	140
"Rock," sandy.....	3	88	Sandstone (water-bearing)....	18.5	158.5
Shale and clay.....	10	98			

Ebensburg Coal Co., near Colver a

[No. 405. Authority, D. Fleming, supt.]

		Thick- ness (feet)	Depth (feet)			Thick- ness (feet)	Depth (feet)	
Allegheny formation	Soil and decomposed rock	27	27	Pottsville formation	Homewood sandstone member	Sandstone, white	37.5	300
	Clay, tough	10	37			Sandstone, dark.	29	329
	Slate, black	35	72			Shale, sandy	11	340
	Sandstone, gray	42	114			Shale, black, sandy	14	354
	Sandstone, black	11	125			Sandstone, hard gray	13	367
	Slate, black	17	142		Mercer shale member	Coal (Mercer)	1	368
	Sandstone, with streaks of slate	38	180			Fire clay	2	370
	Sandstone, black	6	186		Slate, white	11	381	
	Sandstone, gray (water- bearing)	4	190		Connoque- nessing sandstone member	Sandstone, brown	5	386
	Sandstone, hard	1	191			Sandstone, hard, white	52	438
	Slate, black	12	203			Sandstone, brown	8	446
	Coal (Lower Kittan- ning, B)	4	207			Sandstone, green	6	452
	Fire clay	20	227			Mauch Chunk shale	Shale, green	12	464
	Sandstone	30	257		Sandstone, green		22	486
	Slate, dark	4	261		Sandstone, gray		11	497
	Coal (Brookville, A)	1.5	262.5		Sandstone, hard, white		24	521
			Sandstone, hard, gray	10	531			
			Sandstone, soft, white (water- bearing)	10	541			

^a Tentative geologic correlation by S. W. Lohman.

Nanty Glo Borough Water Co., Nanty Glo

[No. 409. Authority, J. J. Conrad, commissioner]

	Thick- ness (feet)	Depth (feet)		Thick- ness (feet)	Depth (feet)
Soil and decomposed rock	36	36	Shale, white	12	152
Sandstone	20	56	Sandstone (crevice near base		
Shale, dark	36	92	water-bearing)	37	189
Sandstone	29	121	"Rock," red	1	190
"Rock," red (some water)	19	140			

Colver Water Co., Vctera

[No. 420. Authority, D. Flemming, supt.]

	Thick- ness (feet)	Depth (feet)
Soil and decomposed rock	22	22
Fire clay, hard	38	60
Shale, sandy	15	75
Sandstone (water-bearing)	20	95
Slate, black	3	98
Coal (Lower Freeport, D)	3	101

E. L. Williams, Parktown

[No. 449. Authority, W. A. Horner, driller]

	Thick- ness (feet)	Depth (feet)
Soil and decomposed rock	20	20
Sandstone, hard (Saltsburg)	50	70
Fire clay	30	100
Slate (water-bearing)	45	145
Sandstone, hard	10	155

B. F. Heckler, near Walnut Grove

[No. 450. Authority, R. Phaler, chief engineer Berwind-White Coal Co.]

	Thick- ness (feet)	Depth (feet)		Thick- ness (feet)	Depth (feet)
Sandstone (Saltsburg)	35	35	Limestone, gray (Lower		
Shale, sandy	40	75	Freeport)	5	207
Sandstone	10	85	Shale and fire clay	30	237
Fire clay and shale	70	155	Sandstone, medium hard	10	247
Slate, black (well plugged at			Sandstone, very hard	13	260
this depth)	5	160	Coal (Upper Kittanning, C')	3.5	263.5
Coal (Upper Freeport, E, mined			Shale, sandy	6	269.5
out and drained)	3	163	Slate and clay	60	329.5
Slate, dark	6	169	Shale, dark, sandy	24	353.5
Shale and fire clay	18	187	Slate, black	7	360.5
Shale, dark, sandy	9	196	Coal (Lower Kittanning, B)	3.5	364
Shale, black	4	200	Fire clay	11	375
Coal (Lower Freeport, D)	2	202			

Partial log of mine shaft of Berwind-White Coal Co., near St. Michael

[No. 454. Authority, R. Phaler, chief engineer Berwind-White Coal Co.]

	Thick- ness (feet)	Depth (feet)		Thick- ness (feet)	Depth (feet)
Surface	23.6	23.6	Sandstone	19	215
Shale	2	25.6	Slate, black . . . . .	.5	215.5
Fire clay, sandy	7.7	33.3	Sandstone	19.5	235
Shale, dark	12	45.3	Sandstone, dark	7	242
Sandstone	7.8	53.1	Shale, dark, sandy	9	251
Shale, dark (Fossil shells)	10.2	63.3	Coal . . . . .	.3	251.3
Coal . . . . .	.8	64.1	Shale, dark (water ring No. 3,		
Fire clay	24.7	88.8	865 gallons a minute)	10.5	261.8
Shale, red, and fire clay (water			Coal	1.2	263.0
ring No. 1, 200-300 gallons a			Interval		
minute)	23.2	112	Coal (Upper Freeport, E)		474
Fire clay, sandy	17	129	Interval		
Shale, light and dark	7	136	Coal (Upper Kittanning, C')		577
Shale, dark	12	148	Interval		
Sandstone	1	149	Coal (Middle Kittanning, C)		637
Coal	1.5	150.5	Interval		
Fire clay, sandy	27.5	178	Coal (Lower Kittanning, B)		666
Shale, light, sandy	7	185	Interval		
Sandstone	5	190	Bottom of shaft		907
Shale, light, sandy (water ring					
No. 2, 674 gallons a minute)	6	196			

CENTRE COUNTY

Area 1,146 square miles. Population (1930) 46,294.

GEOGRAPHY

Centre County is the largest county in the area covered by this report and the second largest in Pennsylvania. As its name implies, it contains the geographic center of the State. It is mountainous and rather sparsely populated, with only about 40 inhabitants to the square mile, as against 215 for the entire State. Most of the people in Centre County live in the fertile Nittany and Penns Valleys and on the plateau at Philipsburg. Bellefonte, State College (home of Pennsylvania State College), and Philipsburg, with populations in 1930 of 4,804, 4,450, and 3,600, respectively, are the only boroughs with 1,000 or more inhabitants. Only about 34 percent of the total land area is devoted to farming, the remainder consisting principally of forested ridges. Considerable limestone is quarried in Nittany Valley, and coal and flint clay are mined on the plateau in the western part of the county. The Federal census of 1929 credits the county with only 58 manufacturing establishments whose products were valued at \$5,000 or more annually each.

GEOLOGY

The geologic formations exposed in Centre County range from the Warrior limestone, of Upper Cambrian age, to the Conemaugh formation, of Pennsylvanian age (pl. 1). The character and water-bearing properties of the formations are given in the first half of this report. The oldest formations, the Cambrian and Ordovician limestones and dolomites, crop out in the large fertile valleys that characterize the eastern part of the county, including Nittany, Penns, and Brush Valleys. The youngest rocks, the Carboniferous formations, crop out only on and west of the Allegheny Front. The Devonian rocks crop out as a long, straight band in Bald Eagle Valley and on the east slope of the Allegheny Front (pl. 4, A). The Silurian rocks form the slopes and crests of the high ridges east of Bald Eagle Valley. The Allegheny Mountains, the highest part of the county, are formed by the upturned edge of the Pocono formation. The highest ridges east of the Allegheny Mountains are formed by the Tuscarora quartzite, the next highest by the Oswego sandstone. The most pronounced folds are the Nittany anticline, Penns Valley anticline, and Nittany Mountain syncline. There are numerous minor folds, and within Nittany Valley there are several faults.

The Allegheny Front traverses the western part of the county, so that part of the county lies in the plateau province, and the

remainder lies in the Ridge and Valley province. A view of the Allegheny Front in Centre County is shown in plate 4, A., The Allegheny Mountains in the southwestern part rise to an altitude of 2,580 feet, the highest point in the county. Altitudes of more than 2,400 feet are found in the Seven Mountains district, in Harris Township. Bald Eagle Creek crosses the Clinton County line at an altitude of about 580 feet, the lowest point in the county. The maximum relief is therefore 2,000 feet.

Centre County is drained largely by the West Branch of the Susquehanna River, through Bald Eagle and Moshannon Creeks. Spruce and Halfmoon Creeks carry part of the drainage in Nittany Valley southward to the Juniata River, and Penn Creek carries the drainage of the southeastern part of the county eastward to the Susquehanna River at Selinsgrove.

GROUND WATER

The Cambrian and Ordovician limestones and dolomites are the most productive water-bearers in Centre County and give rise to some of the largest springs in the area, including spring 115 (pl. 15, B), spring 118, Bellefonte Spring (no. 119, pl. 15, A), spring 121, spring 143, Rising Spring (no. 144), Thompson Spring (no. 165), spring 178, and several others for which no descriptions are given in the tables. The variation in the discharge of Thompson Spring (no. 165) is shown in plate 10 and figure 5. (See also plate 14.) The Devonian formations and most of the Silurian formations have not been exploited beyond domestic needs in Centre County, although in the adjacent Blair and Clinton Counties some of them are important water-producers. The Pottsville formation is very productive in Philipsburg and vicinity.

Ground water for domestic and stock use is derived largely from springs and dug wells but in part from drilled wells and cisterns. Many of the villages, such as Blanchard, Nittany, Moshannon, and Hublersburg, are supplied largely from dug wells; others, such as Snyderstown and Potter Mills, are supplied chiefly by springs. In many places in Nittany Valley the water table stands so far beneath the surface that deep wells must be drilled for water, as in Zion and in most of the areas underlain by the Gatesburg formation, known as The Barrens, Rocky Ridge, and Gatesburg Ridge. The dug wells obtain water principally from soil or decomposed rock, as there is very little alluvium along most of the streams except locally along Bald Eagle Creek. The water levels in a shallow dug well in Central City (no. 106) are measured weekly. (See pp. 36-39.)

There is relatively little industrial use of ground water in Centre County, but some is used for cooling and condensing in dairies, ice plants, and breweries. Large quantities of ground water are used for public supply, as described below.

Records were obtained of only two flowing wells in Centre County (nos. 97 and 186), but it is possible that other flowing wells might be obtained in the Houtzdale syncline along Moshannon Creek, in the western part of the county.

Analyses of 6 samples of water collected from wells and springs and of 2 samples collected from small mountain streams are tabulated below. None of the samples contained iron in objectionable amounts, but excess iron is reported from some of the Pottsville and Marcellus waters (wells 95, 97, 107, and 108). Most of the waters from the Cambrian and Ordovician limestones and dolomites are of good quality and are only moderately hard, as indicated by analyses 119, 163, 164, and 172. Very hard water was obtained in well 104 from the Cayuga group. Very soft water is obtained from numerous small springs issuing from the ridges composed of the Tuscarora, Juniata, and Oswego formations, the water being comparable in quality to that found in the small mountain streams (analyses A, B). The quality of water to be expected from the different geologic formations is summarized on pages 80, 81.

PUBLIC SUPPLIES

The two largest boroughs and most of the smaller places in Centre County are supplied with ground water or with a combination of surface and ground water. Philipsburg is the only large borough supplied wholly by surface water, and surface water supplies also Aaronsburg, Boalsburg, Howard, Milesburg, Millheim, Mingoville, Monument, Mount Eagle, Orviston, and the State penitentiary at Rockview. The 15 public supplies using ground water or a combination of ground and surface water are described below.

Bellefonte, the county seat (population 4,804), is supplied by the Bellefonte Borough Water Co. from Bellefonte Spring (no. 119), after which the borough was named. A view of Bellefonte Spring, the second largest spring in Pennsylvania, and the main pumping plant is shown in plate 15, A. Water from the spring is pumped by one of five pumps directly into the distributing mains, and the excess water flows into a 370,000-gallon concrete reservoir. Three of the pumps are operated by water power, two of 1,200 and 1,500 gallons a minute capacity being operated by Spring Creek and one of 150 gallons a minute capacity by the

overflow of Bellefonte Spring. For emergency use, there are also two electrically driven centrifugal pumps with a capacity of 950 and 1,200 gallons a minute, which are located at another plant. A few houses above the reservoir in the highest part of the borough are served by a 50-gallon a minute booster pump operating in connection with a pneumatic pressure tank. The pressure in the lowest part of the borough is about 90 pounds to the square inch. The average daily consumption is about 2,500,000 gallons, part of which is used by the railroad and several industries. There are 88 fire hydrants in the system. There are no meters, and owing to the abundance of water available no attempt is made to conserve water. The water does not require treatment and is of good quality, as shown by analysis 119.

Centre Hall (population 658) is supplied by the Centre Hall Borough Water Co. from five small springs that issue from the Oswego sandstone on Nittany Mountain, northwest of the borough. The five springs yield a total of about 100 gallons a minute in wet seasons but are inadequate in dry seasons, when two drilled wells (nos. 147 and 148) augment the supply. The water from the springs and wells discharges into a 380,000-gallon open concrete reservoir, whence it is distributed by gravity. Pressures in the borough range from 80 to 120 pounds to the square inch. There are 25 fire hydrants in the system. The daily consumption is not known, but all the inhabitants are supplied. The water is not treated in any way. The water from all the springs and well 147 is reported to be very soft, but the water from well 148 (in limestone) is moderately hard.

In Clarence 33 families are supplied by the Clarence Water Co. owned by J. F. Uzzell. The supply comes from a spring in a sandstone in the Pocono formation, which discharges about 20 gallons a minute and flows into two reservoirs, whence it is distributed by gravity. The reservoirs are formed by small concrete dams across a ravine, the upper reservoir, which is used, discharging into the lower one, which is held in reserve. There are two fire hydrants in the system. The daily consumption is not known. Chloride of lime is added to the water at regular intervals. The supply was reported to have been very low in 1930. Several drilled wells in Clarence 100 to 200 feet deep are reported to yield water of poor quality.

Madisonburg is supplied by the Madisonburg Water Supply Co. from three small springs that issue from the Oswego sandstone on the ridge to the north. The water flows into a 1,200-

gallon concrete reservoir and is distributed by gravity. About 50 families are supplied. The water is not treated in any way.

Pine Grove Mills is supplied from spring 177 by the Pine Grove Water Co. The water flows into two covered masonry reservoirs holding 1,900 and 13,000 gallons, and is distributed by gravity to 104 houses and stores and to 1 fire hydrant. The water is reported to be very soft and is not treated in any way.

Pleasant Gap is supplied by the Pleasant Gap Water Supply Co. The main source is 4 springs that issue from the Juniata formation along the canyon of Gap Run. A small tributary of Gap Run is available as an emergency supply. Well 133 was drilled for a supplementary supply but is not used, owing to the poor quality of the water and the small yield. The springs discharge into a 72,000-gallon covered concrete reservoir near the well, and the water is distributed by gravity at house pressures ranging from 90 to 135 pounds to the square inch. About 200 families and 1 limestone quarry are supplied. There are 15 fire hydrants in the system. The spring water is not treated, but chloride of lime is added to the stream water when this supply is used.

Port Matilda (population 508) is supplied by the Port Matilda Water Co. from two springs on Bald Eagle Mountain. One spring, reported to yield soft water, issues from the bottom of one of two small reservoirs; the other (no. 190), which issues above the reservoir, yields moderately hard water, as shown by analysis 190. The water is distributed by gravity at a maximum pressure of about 110 pounds to the square inch. The water is not treated.

Rebersburg and Smulton are supplied by the Rebersburg & Smulton Water Co. from a spring on the mountain south of Smulton. The spring presumably issues from the Oswego sandstone and is reported to yield about 200 gallons a minute. The reservoir supplying Rebersburg holds 28,000 gallons and one supplying Smulton holds 600 gallons. The water is distributed by gravity. About 70 people in Smulton and 300 people and 10 fire hydrants in Rebersburg are supplied. The water is not treated.

Snow Shoe (population 520) is supplied by the Snow Shoe Water Co. from a small stream and one spring about 2½ miles southeast of the borough, about 75 percent of the water being obtained from the stream. Storage is furnished by two open reservoirs near the spring having a total capacity of 100,000 gallons, and the water is distributed by gravity. Pressures in the borough range from 25 to 60 pounds to the square inch. About 112 families and 12 fire hydrants are supplied, and in addi-

tion considerable water is sold to the Pennsylvania Railroad for locomotive boilers. The water is chlorinated.

About 25 families and 1 silk mill in Spring Mills are supplied by the Rising Spring Water Co. from two small springs on Egg Hill. The water is stored in a 33,000-gallon concrete reservoir, is distributed by gravity, and is not treated. Another group of 15 to 18 families is supplied by the Spring Mills Water Co. from one spring and one dug well in the Reedsville shale on the side of Egg Hill. Water flows from the dug well through a pipe driven into the downhill side. The water is stored in a 150-gallon tank and a 1,600-gallon concrete reservoir and is distributed by gravity. It is not treated.

State College (population 4,450) is supplied by the State College Water Co. The main supply comes from an impounding dam on Roaring Run at the gap in Tussey Mountain one mile from Shingletown and $3\frac{1}{2}$ miles southeast of State College. From the impounding reservoir, which holds 350,000 gallons, the water flows by gravity to a 1,000,000-gallon standpipe just outside the borough and is distributed by gravity. There are also two auxiliary wells, one at the standpipe (no. 164) and one below the Shingletown Gap reservoir (no. 172), from which water is pumped directly into the mains by two centrifugal pumps. Pressures in the borough range from 30 to 70 pounds to the square inch. The daily consumption ranges from 400,000 to 860,000 gallons. The stream furnishes all the water needed in wet weather, but in dry weather, when the stream flows less than 400,000 gallons a day, the wells are used. There are 73 fire hydrants. Two ice cream manufacturers, one ice plant, and the Bellefonte Central Railroad are supplied, and there is an emergency interconnection with the private water system of the Pennsylvania State College (described below). Analyses of the water from the stream and wells tabulated below (nos. 164, 172, and A) show that the stream water is very soft, that from well 172 is relatively soft, and that from well 164 is only moderately hard. The water from all sources is chlorinated. Several unsuccessful wells (nos. 173-176) were drilled in Shingletown Gap before well 172 (see log) was finally put down.

The water supply of Pennsylvania State College, in the borough of State College, comes largely from a drilled well on the campus (no. 163) and in part from a small stream at Musser Gap, on Tussey Mountain, about $3\frac{1}{2}$ miles to the south. Three additional wells were recently put down a mile north of the borough, two of which (nos. 159-161; see logs) may be used to increase the

supply. From a small catch basin in the stream at Musser Gap the water is distributed by gravity, and water from the well is pumped directly into the mains by a centrifugal pump. The average pressure on the campus is about 60 pounds to the square inch. There are 45 fire hydrants in the system, and there is an emergency interconnection with the borough water system. When the college is in session the average daily consumption is about 350,000 gallons, 70 percent of which comes from the well. Of this amount 33,000 gallons is used by the dairy. All the water is chlorinated. As shown by analyses B and 163, the stream water is very soft, and the well water is moderately hard.

Unionville (population 304) is supplied by the Unionville Water Co. from four small limestone springs on Bald Eagle Mountain, east of the borough. The springs discharge into a 40,000-gallon covered concrete reservoir, from which water is distributed by gravity at an average pressure in the borough of 85 pounds to the square inch. There are 15 fire hydrants. About 90 families and 1 ice plant are supplied.

Woodward is supplied by the Woodward Water Co. from two small springs that issue from the Oswego sandstone in Woodward Gap, to the south. A third spring is held in reserve. The springs discharge into a 1,900-gallon concrete and stone reservoir, whence water is distributed by gravity at an average pressure of 125 pounds to the square inch. There are 8 fire hydrants. About 120 people are supplied, and the water is not treated in any way.

Typical wells and springs in Centre County

No. on pl. 2	Location	Owner or name	Topographic situation	Altitude (feet) ^a	Type of supply ^b	Depth (feet)	Diameter (inches)	Principal water-bearing bed				Length of casing (feet)	Depth to water level (feet)	Method of lift ^c	Yield (gallons a minute)	Use of water ^f	Remarks
								Depth to top of bed (feet) ^e	Thickness (feet)	Character of material ^d	Geological horizon						
Rush Township																	
95	Philipsburg,	Philipsburg Brew- ing Co.	Valley	1,420	Dr	425	10-8	180	100±	Sandy shale	Pottsville,....	180	15±	T	75	C	Reported draw-down 50 feet at 75 gallons a minute. Well formerly 175 feet deep, but deepened and cased below coal in unsuccessful attempt to eliminate iron-bearing water. Some coal encountered at 230 feet. Very little water reported in sandstones below 280 feet. Temperature 53°F.
96	do.	Pennsylvania State Taxidermy Co.	do.	1,440	Dr	160	6	(?)	(?)	Sandstone...	do.	18	35±	N	(?)	N	Well formerly owned and used by Hoffman Ice Cream Co. for cooling.
97	1 mile east of Oseola	Pennsylvania Rail- road Co.	do.	1,460	Dr	180	6	NB	(?)	do.	do.	100±	+5	S	160	R	Flows about 40 gallons a minute. Reported draw-down 12 feet below ground surface at 160 gallons a minute after 24 hours. Used only for emergencies. Water contains excess iron.
98	Sandy Ridge,.....	General Refrae- ratories Co.	Upland	1,920	Dr	701	8	(?)	(?)	Sandstone?	Pottsville or Pocono	?	100±	P	17	P,I	Supplies 10 houses and brick plant. Water reported good.
99	do.	Pennsylvania Rail- road Co.	do.	1,930	Dr	60	?	NB	(?)	Sandstone...	Pottsville,....	22	20±	H	5±	D	
100	1.1 miles southeast of Sandy Ridge	O. F. Adamitz,....	do.	2,190	Dr	126	8	120	6	do.	do.	15	45±	P	10+	D	No water above 90 feet. Water reported soft.
101	Black Moshannon School	State of Pennsyl- vania	Valley	1,880	Dr	30	6	28	2	do.	do.	28	2.5±	H	5-10	D	Water reported good.
102	0.3 mile southeast of Black Mo- shannon School	? (club).....	do.	1,880	Dr	45	6	20	15	do.	do.	20	20±	P	10±	D	

103	Ifoward Township 2.1 miles northwest of Howard	C. I. Yarrison.....	740	Dr	140	6¼	NB	(?)	Gray shale...	Portage.....	35	2	S	3	D	Water reported to contain hydrogen sulphide.
104	Howard.....	Sheffield Farms, Inc.	660	Dr	625±	8	NB & 350±	(?)	(?)	Cayuga.....	(?)	?	P	80±	N	Water reported too hard for boiler use. Reported large draw-down.
105	Boggs Township															Water reported hard.
106	0.6 mile southeast of Curtin Central City.....	H. L. Curtin..... O. V. Scholl.....	700 700	Dr Du	80 9.4	6 48± sq.	NB 4	(?) 5.4	Limestone? Gravel.....	Oriskany..... Recent.....	(?) 9.4	1.3 to 6	P N	3-5 30±	D N	Loam 1 foot; sand, 3 feet; gravel 5.4 feet; bottom, shale. 100 yards from stream. U. S. Geological Survey observation well; see pp. 35-39.
107	do.	Mr. Walker.....	700	Dr	93	6	NB	(?)	Black shale.	Marcellus.....	33	?	I	3	D	Water reported to contain excess iron. Some water reported at depth of 30 feet.
108	do.	Luther Peters.....	700	Dr	112	6	110	2	do.	do.	76	?	N	30±	N	Not used because of excess iron and hydrogen sul- phide in water. Some water reported at depth of 70 feet, but cased off.
109	0.5 mile northwest of Wingate	J. Davidson.....	760	Dr	122	6	120	2	Gray shale...	Harrell.....	20	30±	H	20±	D,S	
110	Union Township															
111	0.8 mile northwest of Wingate 0.4 mile north of Unionville (Fleming post office)	John Martin..... John Askins, (formerly)	760 1,080	Dr Dr	376 142	6 6	(?) NB	(?) (?)	Gray sandy shale do.	Portage..... Brallier.....	30 20	30± 60±	H H	1½ 20±	D D,S	
112	Huston Township Julian.....	J. H. Turner.....	850	Dr	100-150	6	?	(?)	Shale?.....	Hamilton.....	(?)	15±	I	(?)	D	
113	Benner Township															
114	0.3 mile southeast of Hunter Park 1.1 miles southeast of Stevens	Lyman Bickle..... Boyd Corl.....	1,030 1,070	Dr Dr	207 231	6 6	204 230	3 1	Channel in limestone do.	Stonehenge..... do.	90 (?)	45± 196	P P	6+ (?)	D,S D,S	Reported large yield. Well reported dry down to 200 feet.

Typical wells and springs in Centre County—Continued

No. on pl. 2	Location	Owner or name	Topographic situation	Altitude (feet) ^a	Type of supply ^b	Depth (feet)	Diameter (inches)	Principal water-bearing bed				Length of casing (feet)	Depth to water level (feet)	Method of lift ^c	Yield (gallons a minute)	Use of water ^f	Remarks
								Depth to top of bed (feet) ^e	Thickness (feet)	Character of material ^d	Geologic horizon						
115	1.5 miles west of Axemann	Bellefonte Fish Hatchery	Valley	820	Sp	.....	.....	.....	.....	Channel in dolomite	Gatesburg....	.....	.....	F	3,000	F	Yield reported measured in 1933. Water cloudy after rain. Temperature 52°F. See pl. 15, B. Some dry openings about 100 feet; none below.
116	0.9 mile southwest of Axemann	State penitentiary (H. Hoy farm)	Hillside	1,050	Dr	227	6	100	0.4±	Channel in limestone	Stonehenge....	7	100	P	4.5	D,S	
117	0.1 mile north of Pleasant Gap station	Daniel Shuey.....	Valley	900	Dr	50	8½	35	0.5	Channel in dolomite	Bellefonte....	10	15±	H	5+	D	
118	0.1 mile south of Pleasant Gap station	Bellefonte Fish Hatchery	do.	900	3 Sp	.....	.....	.....	.....	do.	do.	.....	.....	F	800 & 2,700±	F	2 springs yield 800 gallons a minute combined. Shugart Spring yields 2,700 to 3,000 gallons a minute. Temperature 52°F. Shugart Spring gets cloudy; others do not.
119	Spring Township Bellefonte.....	Bellefonte Borough Water Dept., Bellefonte Spring	do.	740	Sp	.....	.....	.....	.....	Channel in limestone or dol.	Axemann or Bellefonte	.....	.....	F	14,000±	P	Water bubbles up in pool 77 by 66 by 8 feet. Re- ported second largest spring in State. About 2,000,000 gallons a day used. Temperature 51°F. See analysis and plate 15, A.
120	0.7 mile east of Bellefonte	Triangle filling station	Hillside	900±	Dr	143	6	NB	?	Thin-bedded limestone	Stonehenge....	30±	40±	P	4.5	D	No large openings re- ported. Reported tested at 30 gallons a minute. Yield reported by owner; variable.
121	0.5 mile south of Bellefonte	Titan Metal Mfg. Co.	Valley	780	Sp	.....	.....	.....	.....	Limestone..	do.	.....	.....	F	1,000±	I	
122	Axemann.....	Mr. Johnson.....	do.	840	Dr	37	6¼	NB	(?)	Limestone or dol.	Stonehenge or Nittany do.	20	18±	P	5±	D	No large openings re- ported.
123	do.	Mr. White.....	do.	840	Dr	102	6	NB	(?)	do.	do.	12	60±	P	20±	D	Do.
124	2.1 miles east of Bellefonte	Harvey Corman...	Hillside	1,000	Dr	200	(?)	NB	(?)	do.	Beekmantown	60	130	P	15	S	Some water reported at 140 feet. Clay-filled channels cased off.

	1.7 miles southwest of Zion	Roy Zimmerman...	Upland	1,060	Dr	214	6	208	1	Channel in limestone or dol.	do.	76	174±	P	20+	D.S	Clay-filled channels east off.
125	2.2 miles southwest of Zion	Kyle Corman.....	Slope	1,010	Dr	280	6	275	.....	Limestone or dol.	do.	18	160±	P	4½	D.S	No large openings encountered.
126	1.8 miles southwest of Zion	Transcontinental & Western Air, Inc.	do.	1,040	Dr	367	6	160±	.....	do.	do.	26	8±	P	3	D	Do.
127	1.5 miles north of Pleasant Gap	Harvey Hoy.....	do.	1,020	Dr	160	6¼	NB	.....	do.	Beekmantown	20	100±	P	10±	D.S	Do.
128	1 mile northeast of Pleasant Gap	William Hoffman...	do.	1,070	D	85	6	.....	.....	Dolomite...	Belleville.....	15	70±	N	(?)	N	Yield reported very small. Drilling stopped by owner.
129	1.5 miles northeast of Pleasant Gap	White Rock Quarry (farm)	Hillside	1,140	Dr	120	8	NB	.....	Limestone...	Trenton or Carlm?.....	18	95±	P	1±	D	No large openings encountered. Drilling stopped because of lost drill in well.
130	1 mile northeast of Pleasant Gap	Frank Brooks.....	Slope	1,070	Dr	175	6	168	7	Dolomite...	Belleville?...	143	140±	P	20+	D	Other openings at 42 and 110 feet, but upper waters reported poor or muddy and were eased off.
131	0.4 mile east of Pleasant Gap	R. C. Noll.....	Hillside	1,400±	Dr	102	8½	(?)	(?)	Sandstone...	Oswego.....	0	5±	N	(?)	N	Test hole for limestone.
132	0.5 mile southeast of Pleasant Gap	Pleasant Gap Water Co.	Canyon	1,240	Dr	240	6	(?)	(?)	Black shale.	Reedsville...	46	30±	N	60-	N	Drilled for public supply but rejected; water has bad taste due to hydrogen sulphide. Water lowered nearly to bottom by pumping 60 gallons a minute.
133	Marion Township	M. S. Betts.....	Valley	940	Dr	95	6	NB	(?)	Channel in limestone or dol.	Lower or Middle Ordovician	20	20±	H	3-5	D	Reported tested at 40 gallons a minute.
134	1 mile northeast of Jacksonsville	Joel B. Stover.....	do.	1,000	Dr	176	6	170	0.1±	do.	Lower Ordovician	40	16 to 30	S.P	6+	D.S	Reported large yield.
135	1 mile northeast of Zion	William Corman...	Slope	1,070	Dr	128	6¼	NB	(?)	do.	Lower or Middle Ordovician	(?)	?	P	(?)	D	Also use cistern.
136	0.5 mile northwest of Hubersburg	B. R. Ingram.....	do.	1,000	Dr	120	6	NB	(?)	do.	Upper Cambrian or Lower Ordovician	(?)	?	P	5	D.S	Well formerly dug 30 feet deep but went dry in summer of 1932. Clay seams ceased off. Temperature 52°F. Also use cistern.
137	Hubersburg.....	C. L. Krape.....	do.	920	DD	117	6	117	(?)	do.	Lower or Middle Ordovician	112	52	H	22±	D	

Typical wells and springs in Centre County—Continued

No. on plat.	Location	Owner or name	Topographic situation	Altitude (feet) ^a	Type of supply ^b	Depth (feet)	Diameter (inches)	Principal water-bearing bed				Length of casing (feet)	Depth to water level (feet)	Method of lift ^c	Yield (gallons a minute)	Use of water ^d	Remarks
								Depth to top of bed (feet) ^e	Thickness (feet)	Character of material ^d	Geologic horizon						
139	0.6 mile southwest of Snydertown	Frank Long.....	Valley	900	Dr	46	6	45	1	Channel in limestone or dol.	Lower or Middle Ordovician	9	12	H	30±	D,S	
140	Miles Township																
140	1.8 miles east of Rebersburg	John Boob.....	Slope	.....	Dr	160	6	(?)	(?)	Limestone or dol.	do.	(?)	?	P	4-5	D,S	
141	Haines Township																
141	0.6 mile east of Fiedler	L. P. Fiedler.....	do.	.....	DD	78	6	(?)	(?)	do.	do.	(?)	10	H,P	3	D,S	
142	Penn Township																
142	Coburn.....	Sheffield Farms, Inc.	Valley	.....	Dr	120	8	NB	(?)	Limestone	Trenton.....	(?)	?	P	50	C	Water contains hydrogen sulphide.
143	Gregg Township																
143	2.6 miles northwest of Spring Mills	W. P. Campbell....	do.	1,160	Sp	.....	.....	.....	.....	do.	Trenton?	.....	.....	F	6,000	E	Water issues from concealed exit of Penns Cave. Water impounded by dam and generates electricity. Yield measured by owner. Forms head of Penn Creek.
144	Spring Mills.....	Rising Spring, L. H. Dennis and H. C. Fetteroff	do.	1,100	Sp	.....	.....	.....	.....	do.	do.	.....	.....	F	(?)	I	Issues from small sink hole reported to be more than 165 feet deep. Yield estimated at several thousand gallons a minute. This spring and Penn Creek run flour mill.
145	do.	Sheffield Farms, Inc.	do.	1,200	Dr	107	8	NB	(?)	do.	Trenton.....	30	20±	P	200±	I	Water reported hard and iron-bearing. Boiler compound used. Reported yield of 400 gallons a minute with air lift.

	do.	Dairymen's League Cooperative Assn., Inc.	do.	1,200	Dr	280	6	NB	(?)	do.	(?)	?	P	50	C.I	Water contains hydrop- sulphide.
146	Potter Township 0.1 mile north of Centre Hall	Centre Hall Bor- ough Water Co.	Hillside	1,500±	Dr	129	6	NB	(?)	Shale?.....	(?)	12±	P	30	P	Auxiliary supply. Pumps dry after 2 days pump- ing.
148	Centre Hall.....	do.	do.	1,460	Dr	300+	6	NB	(?)	Limestone.	(?)	12±	T	50	P	Well penetrates lower part of Reedsville shale. Auxiliary supply.
149	0.7 mile east of Centre Hall	Mr. Detweiler.....	Ridge	1,820	Dr	132	8-6 ¹ / ₄	NB	(?)	Sandstone..	40	82±	P	5±	D	
150	do.	M. E. Coldren.....	do.	1,810±	Dr	150	6	NB	(?)	do.	20-5	?	P	3±	D	
151	0.3 mile southeast of Centre Hall	Sheffield Farms, Inc.	Valley	1,280±	Du	22	168±	NB	(?)	Limestone	22	14±	S	(?)	C.I	Pumped at about 50 gal- lons a minute, but part of water from conden- sers returned to well.
152	0.9 mile southeast of Centre Hall	Dr. Brocker.....	Knoll	1,300+	Dr	216	6	213	3	Channel in limestone	42	100±	P	6	D,S	Reported tested at 30 gal- lons a minute with small draw-down.
153	0.1 mile north of Centre Hill	P. P. Henshell, ...	Slope	1,220	Dr	127	6	125	1	do.	8	91	P	4 ¹ / ₂	D	Do. Some water at 95 feet.
154	0.1 mile west of Potter Mills, ...	T. A. Davis.....	Hillside	1,240	Dr	122	6	NB	(?)	Limestone..	23	65±	H,P	6-	D	Will not yield more than 6 gallons a minute. 54 feet of Reedsville shale; rest limestone.
155	2.1 miles south of Potter Mills	R. D. Rearick.....	do.	1,720	Dr	43	6	NB	(?)	Red shale...	22	30±	H	15	D	Will not yield more than 15 gallons a minute.
156	Tusseyville.....	Mr. Klinefelter....	Valley	1,200	Dr	50	6 ¹ / ₄	NB	(?)	Black shale.	15±	20±	H	3-5	D	
157	2.1 miles west of Tusseyville.....	Roy Garbick.....	do.	1,220	DD	187	6 ¹ / ₄	(?)	(?)	Limestone.	30	107	P	3±	D	
158	College Township Houserville.....	Mr. Aleman.....	do.	930	Dr	44.5	6	43	1-5	Channel in dolomite	23	8±	H	30	D	
159	1 mile north of State College	Pennsylvania State College	do.	*1,039	Dr	270	12- 4 ¹ / ₂	55	(?)	Weathered dolomite		55	N	(?)	N	Well 2. Abandoned be- cause of small yield. Water level measured Nov. 16, 1933. See log. Well 3, 630 feet southwest of well 2. Water level measured June 22, 1934. Draw-down 83 feet after 10 hours' pumping from 460 to 260 gallons a min- ute. Shot with 100 pounds of dynamite at depth of 123 feet. See log.
160	do.	do.	do.	*1,045	Dr	334	12-8	SL	...	Sandstone and dol.	5±	45	T	260+	P	

* Altitudes from Pennsylvania State College.

Typical wells and springs in Centre County—Continued

No. on pl. 2	Location	Owner or name	Topographic situation	Altitude (feet) ^a	Type of supply ^b	Depth (feet)	Diameter (inches)	Principal water-bearing bed				Length of casing (feet)	Depth to water level (feet)	Method of lift ^c	Yield (gallons a minute)	Use of water ^f	Remarks
								Depth to top of bed (feet) ^e	Thickness (feet)	Character of material ^d	Geologic horizon						
161	1 mile north of State College	Pennsylvania State College	Valley	*1,048	Dr	305	12	SL	.....	Sandstone and dol.	Gatesburg....	10	43	T	375+	P	Well 1, 645 ft. southwest of well 3. Water level measured June 22, 1934. Draw-down 57 feet after 13 days' pumping 420 to 375 gallons a minute. See log.
162	State College	Mrs. Anna Hartwick	Slope	1,190	DD	207	6	.....	.....	Solid dol....	Nittany.....	0	.....	N	0	N	Drilled for cesspool, but no openings or water encountered.
163	do.	Pennsylvania State College	Valley	1,140	Dr	365	?	350	10	Channel in dolomite	do.	?	80 to 139	A	500	P	Water level reported to fluctuate 59 feet winter to summer, and was -117 feet on June 1, 1934. Temperature 53°F. See analysis.
164	0.1 mile south of State College	State College Water Co.	Knoll	†1,221	Dr	580	12-8	525	3	do.	do.	49	213±	A	185	P	Depth to water level 171 feet in 1921, 213 feet in 1930; yield 255 gallons a minute in 1921. Also 3-foot channel reported at 225 or 325 feet. Temperature 53°F. See analysis. Well penetrates about 400 feet of Axemann limestone.
165	1 mile northeast of State College	Pennsylvania State College, Thompson Spring	Valley	1,010	Sp	.....	.....	.....	.....	Channel in limestone	Axemann.....	.....	.....	F	2,300 to 5,000	N	Yield measured by Ralph R. Cleland. (See pl. 10 and fig. 5.) Runs mill farther downstream. Water contaminated with sewage.
166	1 mile northeast of State College	J. W. & O. H. Bathgate, Bathgate Spring	do.	1,000	Sp	.....	.....	.....	.....	Channel in dolomite	Nittany.....	.....	.....	F	520±	D,S	Yield reported measured in 1904. Temperature 51°F.

* Altitudes from Pennsylvania State College.

† Altitude from State College Water Co.

167	0.1 mile west of Lemont do.	O. W. Houtz.....	do.	1,000	Dr	71	6	NB	(?)	do.	Belleville.....	11	11±	S	20	D	Used as drainage well; takes sewage from septic tank. Reported large opening at bottom. Many openings encoun- tered; see log. Reported draw-down 30 feet at 500 gallons a minute. Yields only 300 gallons a minute after 48 hours' pumping. Water muddy for first 4 hours' pump- ing, then clear. Temper- ature 53° F. See analysis. Shale encountered under 80 feet of alluvium and talus. Very little water. Unsuccessful attempt to hit limestone. All shale, very little water below 50 feet. Reported draw-down 100 feet at 45 gallons a minute. Un- successful attempt to hit limestone. Reported large draw-down at 20 gallons a minute. Unsuccessful attempt to hit limestone. Reported draw-down 100 feet at 55 gallons a min- ute. Unsuccessful at- tempt to hit limestone.
168	Harris Township	John Gorman.....	do.	1,000	Dr	43	6	NB	(?)	do.	do.	22	2±	S	4½	D	
169	Boalsburg.....	Ralph Rischel.....	do.	1,090	Dr	200	6	NB	(?)	do.	do.	160	8±	N	?	N	
170	0.8 mile west of Shingletown	Elmer Witmer.....	do.	1,080	Dr	64	6	64	(?)	do.	Nittany.....	15	16±	H	30+	D, S	
171	Shingletown.....	J. E. Oeman.....	Slope	1,120	Dr	67	6	66	1	do.	Belleville.....	32	30±	H	30	D	Issues from numerous places between walls 2 feet apart and 68 feet long. Yield measured July 18, 1934; reported much larger in wet sea- sons. Water reported very soft. Temperature 48° F.
172	0.5 mile southeast of Shingletown	State College Water Co.	do.	1,200	Dr	301	8-4	SL	.....	Channels in limestone	Carlisle.....	246	30±	T	500	P	
173	0.9 mile southeast of Shingletown	do.	Gap	1,350±	Dr	80	(?)	.....	.....	Black shale.	Reedsville.....	80	(?)	N	(?)	N	
174	0.95 mile southeast of Shingletown	do.	do.	1,370±	Dr	616	8	50±	(?)	do.	do.	23	12	N	45	N	
175	1.0 mile southeast of Shingletown	do.	do.	1,380±	Dr	200	8	50	150	Hard ss.....	Oswego.....	50	10	N	20	N	
176	1.1 miles southeast of Shingletown	do.	do.	1,400±	Dr	342	(?)	48	294	Sandstone and shale	do.	48	2.5	N	55	N	
177	Ferguson Township 0.5 mile south of Grove Mills	Pine Grove Water Co.	Canyon	1,400±	Sp	.....	.....	.....	.....	Sandstone..	do.	.....	.....	F	120±	P	

Typical wells and springs in Centre County—Continued

No. on pl. 2	Location	Owner or name	Topographic situation	Altitude (feet) ^a	Type of supply ^b	Depth (feet)	Diameter (inches)	Principal water-bearing bed				Length of casing (feet)	Depth to water level (feet)	Method of lift ^c	Yield (gallons a minute)	Use of water ^f	Remarks
								Depth to top of bed (feet) ^c	Thickness (feet)	Character of material ^d	Geological horizon						
178	0.2 mile south of Rock Spring	Fry estate, Rock Spring	Stream head	1,160	Sp						Bellefonte			F	1,000±	D,S	Issues from large cave re- ported to extend several hundred feet into cliff. Yield estimated July 16, 1934; reported about 5 times greater yield in wet seasons. Tempera- ture 51°F. Water cloudy after rain.
179	Rock Spring	Fred Rossman	Low ridge	1,200	Dr	78	6	77	1	do.	do.	16	12±	S	5+	D	Tested at 30 gallons a minute.
180	1.3 miles southeast of Fairbrook	Walter Dreibeis	Slope	1,220	Dr	143	6	140	3	do.	Nittany	37	63±	P	6	S	Reported large yield on test. Dry solution chan- nels reported at 20 and 55 feet. Use cistern for house.
181	0.6 mile southeast of Fairbrook	John Gummo	Valley	1,190	Dr	97	6	NB	(?)	Dolomite	Gatesburg	30	77±	P	6—	S	Reported large draw-down at 6 gallons a minute.
182	0.7 mile northeast of Musser	Isaac Harpster	do.	1,120	DD	50	6	30	20	do.	Nittany	30	15±	H	20±	D,S	No large openings re- ported.
183	0.3 mile northeast of Gatesburg	E. E. Rider	Slope	1,300	Dr	300+	8	(?)	(?)	Limestone	Stonehenge	30	205	N	30	N	Old well formerly used for washing iron ore. Cleaned out and tested. Power pump to be in- stalled for watering stock.
184	0.8 mile northeast of Gatesburg	Robert Harpster	Hillside	1,290	Dr	276	6	276	0.1±	Crevice in limestone	do.	90	215±	P	20	D,S	90 feet of clay cased. Two previous attempts en- countered 140 feet of clay.
185	Fatton Township Scotia	Colonel Bull	Valley	1,320	Dr	300±	8	(?)	(?)	Dolomite	Gatesburg	?	?	N	?	N	Drilled about 1894; pumped by steam to wash iron ore. Aban- doned since about 1914; now filled with stones.

186	1.2 miles west of Buffalo Run	D. C. & O. J. Slivery	Hillside	1,720	Dr	110	6	NB	(?)	Red sandy shale	Juniata.....	23	+1	F, I	1-2	D	Flows a small amount. After pumping 40 to 50 gallons water level drops about 10 feet. Temperature 52 F. See analysis. Alternate beds of sandstone and dolomite. Some water in sandstone at 130 feet. Numerous sand layers cased. Reported tested at 20 gallons a minute.
187	1.4 miles southeast of Fillmore	W. E. Brennan....	Low ridge	1,150	Dr	220	6	218	0.1 ±	Crevice in dolomite	Gatesburg....	213	190 ±	P	6	D, S	
188	0.9 mile south of Fillmore	Earl Crust.....	Low ridge	1,140	Dr	247	6	247	0.1 ±	Crevice in dolomite	Gatesburg....	236	207	P	6	D, S	Formerly cased 100 feet, but additional casings installed to keep out sand. Some water at 207 feet. Reported small draw-down at 20 gallons a minute.
189	0.5 mile northeast of Briarty	Dr. Brockerhoff....	Valley	1,010	Dr	122	6	122	(?)	Sandstone...	do.	26	60 ±	H	5 ±	D, S	Sandstone underlies dolomite. Well enters Nittany near fault, apparently tapssilver of Gatesburg. Reported small draw-down at 30 gallons a minute.
190	Worth Township 0.1 mile southeast of Port Matilda	Port Matilda Water Co.	Hillside	1,250 ±	Sp					Limestone...	Tonoloway....			F	20-30	P	Emerges just above reservoir. Temperature 49 F. See analysis.
191	0.3 mile southwest of Stormtown	John Way.....	Slope	1,310	Dr	57	6	57	(?)	Crevice in dolomite	Bellefonte....	10	36 ±	H	5 ±	D	Reported tested at 40 gallons a minute.
192	Taylor Township 0.6 mile northeast of Hannah	J. T. Beckwith....	Valley	1,050	Dr	45	6	NB	(?)	Shale?.....	Hamilton.....	?	5 ±	I	3-5	D	
193	0.8 mile northeast of Gardner.....	Tyrone Rod and Gun Club	Hillside	1,340	Dr	95	6	NB	(?)	Red shale...	Clemung.....	44	20 ±	H	3 ±	D	

^a Altitudes taken from nearest contour on topographic maps unless otherwise indicated. No topographic maps in eastern end of county.

^b Dr, drilled well; Du, dug well; DD, dug and drilled well; Sp, spring.

^c NB, near bottom; SL, see log for water-bearing beds.

^d Dol, dolomite; ls, limestone; sh, shale; ss, sandstone.

^e A, air lift; F, natural flow; H, lift pump, hand-operated; I, pitelcer pump, hand-operated; N, none; P, force pump, power-operated; S, suction pump, power-operated; T, turbine pump.

^f C, condensing or cooling; D, domestic; E, generate power; F, fish hatchery; I, industrial; N, none; P, public supply; R, railroad; S, stock.

Analyses of ground and surface waters from Centre County

[Analyzed by E. W. Lohr. Parts per million. Numbers at heads of columns refer to corresponding numbers in the preceding table and on pl. 2.]

	119	163	164	172	186	190	A	B
Silica (SiO ₂).....	11	7.2	7.2	5.5	.....	8.6	5.3	6.4
Iron (Fe).....	.02	.03	.03	.01	.....	.02	.02	.04
Calcium (Ca).....	27	49	43	14	32	60	1.1	1.9
Magnesium (Mg).....	13	27	21	3.8	17	6.2	.9	1.3
Sodium (Na).....	4.7	5.4	3.5	1.3	{	2.3	1.0	1.1
Potassium (K).....	1.0	1.2	1.1	.7		1.0	.5	.6
Bicarbonate (HCO ₃).....	135	239	202	55	161	193	6.0	12
Sulphate (SO ₄).....	7.7	12	9.4	6.3	b 20	16	3.2	3.7
Chloride (Cl).....	6.2	10	4.8	.6	.8	1.1	.5	.5
Fluoride (F).....	.2	.0	.0	.0	.1	.1	.0	.0
Nitrate (NO ₃).....	2.4	20	18	.24	.0	.30	.05	.05
Total dissolved solids.....	140	257	206	59	a 151	200	16	23
Total hardness as CaCO ₃ (calculated).....	121	233	194	51	150	175	6.4	10
Date of collection (1934).....	July 10	June 14	June 14	June 14	July 16	July 16	June 14	June 14

^a Calculated.

^b By turbidity.

A. Sample of surface water collected from Shingletown Gap Reservoir of State College Water Co., about 0.8 mile southeast of Shingletown. Stream flows about 840,000 gallons a day. Temperature of water in reservoir at time of collection, 55°F.

B. Sample of surface water from Musser Gap Reservoir of Pennsylvania State College, 1.9 miles east of Pine Grove Mills. Collected from tap on campus. Stream flows about 80 gallons a minute in summer.

Log of wells of the Pennsylvania State College, near State College

[Authority, Dept. of Grounds and Buildings, Pennsylvania State College]

Well 2 (no. 159)	Thick- ness (feet)	Depth (feet)	Well 3 (no. 160)	Thick- ness (feet)	Depth (feet)
Earth.....	28	28	Earth.....	3	3
Limestone (loose block).....	2	30	Limestone.....	15	18
Earth.....	7	37	Sandstone, white.....	2	20
Limestone (loose block).....	13	50	Limestone.....	18	38
Earth (lower part water-bearing).....	5	55	Sandstone.....	2	40
Limestone.....	9	64	Limestone.....	12	52
Sandstone.....	4	68	Sandstone.....	2	54
Limestone.....	2	70	Limestone (cavities at 60 and 65 feet).....	20	74
Limestone, disintegrated.....	17	87	Sandstone.....	12	86
Limestone, sandy.....	3	90	Limestone, blue (water-bearing channel at 90 feet).....	19	105
Limestone.....	18	108	Sandstone.....	5	110
Limestone, disintegrated.....	7	115	Limestone, blue.....	8	118
Limestone, gray.....	9	124	Sandstone, white (water-bearing at 124 feet, dynamited at 123 feet, 100-pound charge).....	17	135
Sandstone.....	10	134	Limestone.....	3	138
Limestone.....	3	137	Sandstone.....	1	139
Sandstone.....	5	142	Limestone.....	1	140
Limestone, gray.....	26	168	Sandstone.....	2	142
Sandstone.....	2	170	Limestone.....	2	144
Limestone, gray.....	10	180	Sandstone.....	15	159
Sandstone.....	2	182	Limestone.....	9	168
Limestone, gray.....	6	188	Sandstone, white.....	1	169
Sandstone, hard, gray.....	7	195	Limestone, blue.....	10	179
Limestone, gray.....	5	200	Sandstone.....	5	184
Sandstone.....	1	201	Limestone, blue.....	4	188
Limestone, gray.....	16	217	Sandstone.....	3	191
Sandstone.....	3	220	Limestone.....	5	196
Limestone.....	4	224	Sandstone (cavity at 214 feet).....	28	224
Sandstone.....	2	226	Limestone, gray.....	12	236
Limestone, gray.....	9	235	Sandstone.....	8	244
Sandstone, white.....	6	241	Limestone, gray.....	6	250
Limestone, gray.....	13	254	Sandstone.....	8	258
Sandstone, white, shaly.....	5	259	Limestone, blue.....	5	263
Limestone, sandy.....	11	270	Limestone, gray, sandy.....	12	275
			Limestone, blue.....	6	281
			Sandstone, white.....	8	289
			Limestone, blue.....	5	294
			Limestone, gray, sandy.....	8	302
			Sandstone, white.....	8	310
			Limestone, sandy.....	14	324
			Limestone.....	10	334

Log of wells of the Pennsylvania State College, near State College—Continued

Well 1 (no. 161)	Thickness (feet)	Depth (feet)
Soil.....	21	21
Sandstone (water-bearing at 24 feet).....	37	58
Limestone.....	17	75
Limestone, sandy (water-bearing channels at 76 and 119 feet).....	64	139
Limestone and siliceous oolite.....	6	145
Limestone, sandy.....	15	160
Limestone.....	6	166
Limestone, with sand trains.....	22	188
Sandstone.....	28	216
Limestone (water-bearing channel at 219).....	23	239
Limestone, sandy (water-bearing channels at 241 and 248 feet; reduced from 12 to 8 inches at 252 feet).....	17	256
Sandstone.....	27	283
Limestone, sandy.....	6	289
Sandstone.....	8	297
Limestone, sandy.....	4	301
Sandstone.....	4	305

Log of well of State College Water Co., near Shingletown

[No. 172. Authority, H. A. Orwig, superintendent]

	Thickness (feet)	Depth (feet)
Soil, talus, and weathered limestone (bottom of 8-inch casing, hole reduced from 12 to 8 inches).....	96	96
Limestone.....	74	170
Solution channel.....	3	173
Limestone.....	15	188
Solution channel.....	1	189
Limestone.....	1	190
Solution channel.....	1	191
Limestone.....	12	203
Solution channel.....	3	206
Limestone (test at 250 feet gave 135 gallons a minute; bottom of 6-inch casing at 246 feet, hole reduced to 4 inches).....	47	253
Solution channel (strong flow of water washed drill cuttings away).....	2	255
Limestone.....	5	260
Solution channel.....	1	261
Limestone.....	14	275
Solution channel (water level reported dropped from 35 to 55 feet below the surface).....	7	282
Limestone.....	18	300
Solution channel (strong flow of water, tested at 425 gallons a minute; water level reported to rise from 55 feet to less than 35 feet below the surface).....	1	301

CLEARFIELD COUNTY

Area 1,142 square miles. Population (1930) 86,727.

GEOGRAPHY

Clearfield is the second largest county in the area covered by this report, being only 4 square miles smaller than Centre County, which bounds it on the east. However, with about 76 inhabitants to the square mile, as against 215 for the State, its population is nearly double that of Centre County. With a population in 1930 of 11,595, Du Bois is the largest city in the county and the third largest in the area covered by this report. In addition there are six boroughs with more than 1,000 inhabitants, the largest of which are Clearfield, with 9,221, and Curwensville, with 3,140. The mining of coal and the mining of flint clay are the leading industries, and Clearfield County ranks first in the State in the production of flint clay. Only about 29 percent of its total land area is devoted to farming. The Federal census of 1929 credits the county with 101 manufacturing establishments whose products were valued at \$5,000 or more annually. The county is well served by railroads, including the Pennsylvania, the New York Central, and the Buffalo, Rochester & Pittsburgh (now owned by the Baltimore & Ohio).

The topography is typical of the plateau province. (See pl. 5, A). Boone Mountain, at the northwest corner, rises to an altitude of about 2,370 feet, the highest point in the county, and Allegheny Mountain, in the southeast corner, rises to an altitude of 2,360 feet. Northwest of Curwensville the plateau rises to an altitude of 2,320 feet. The West Branch of the Susquehanna River leaves the county at an altitude of 780 feet, the lowest point in the county. The maximum relief is therefore about 1,590 feet. The greatest local relief is along the deeply incised West Branch of the Susquehanna.

The Continental Divide traverses the northwest corner, so that except for a small area drained by Sandy Lick Creek, Mahoning Creek, and other tributaries of the Allegheny River, Clearfield County is drained by the West Branch of the Susquehanna River. The principal tributaries of the West Branch are Moshannon Creek, Clearfield Creek, Chest Creek, and Bennett Branch of Sinnemahoning Creek.

GEOLOGY

The rock formations exposed in Clearfield County are all of Carboniferous age and range from Pocono (oldest) to the Cone-

maugh (youngest) (pl. 1). Their character and water-bearing properties are described in the first part of this report. The oldest rocks are exposed by the deeply incised streams in the northern and eastern parts of the area. The youngest rocks are preserved from erosion in the interstream tracts and are found in their greatest thickness toward the south and east.

The principal folds trend northeast, and from west to east are the Sabinsville anticline, Caledonia syncline, Chestnut Ridge anticline, Clearfield syncline, Laurel Hill anticline, and Houtzdale syncline. There are some faults, particularly in the Houtzdale quadrangle.

GROUND WATER

The Pottsville formation is the most productive water-bearer in Clearfield County and crops out in or underlies at shallow depth most of the valleys in the county where large supplies are sought. The sandstones in the Allegheny formation are next in importance. The Conemaugh formation (pl. 11, A) is relatively unimportant as a source of water in Clearfield County except along the Caledonia syncline, which passes through Du Bois.

Dug wells and small hillside springs furnish most of the rural and village supplies in Clearfield County, but ground water for industrial or public supplies is recovered largely from drilled wells. The northeastern and north-central parts of the county are forested and contain very little development of any kind. The New York Central Railroad uses several drilled wells for supplying water to locomotives. (See well tables.) This is the only county in the area where any considerable amount of ground water is used for locomotive boilers.

The water level in an unused drilled well (no. 77) is measured weekly. (See pp. 35-39.)

Records were obtained of 7 flowing wells (nos. 1, 12, 23, 24, 31 (2 wells), 64) in Clearfield County, and doubtless there are others. Four of them were observed to flow 40 to 50 gallons a minute. Additional flowing wells can probably be obtained along each of the three major synclines, the Caledonia, Clearfield, and Houtzdale.⁸⁸

⁸⁸ For the location of these synclines see Cathcart, S. H., Geologic structure in the plateau region of northern Pennsylvania and its relation to the occurrence of gas in the Oriskany sand: Pennsylvania Topog. and Geol. Survey Bull. 108, fig. 2, March 1934.

The analyses of 8 samples of ground water and 1 sample of surface water from Clearfield County are given below. Iron is the most objectionable constituent found in the ground waters of the county and occurs in excessive amounts in most of the Pottsville waters. The iron content of three samples of water from the Pottsville (nos. 82, 85, and 87) ranged from 0.40 to 28 parts per million. The method of iron removal used by the borough of Coalport is described under Quality of Water, and the results are indicated by analyses 87a, b, and c. Most of the ground waters in Clearfield County are soft or only moderately hard, but some of the Pottsville waters are very hard. The high nitrate content of water from springs 84 and 90 and wells 89 and 93 probably indicates a mixture of surface water. The sample from well 12, a sodium bicarbonate water, contained a small amount of fluoride, but not enough to be harmful. The quality of water to be expected from the different geologic formations is summarized on pages 80, 81.

PUBLIC SUPPLIES

The city of Du Bois and most of the larger boroughs are supplied with surface water, although prior to 1900 Du Bois was supplied by ground water. Houtzdale, Smoke Run, Brisbin, Ramey, Beulah, Madera, and Janesville are supplied from Mountain Branch, a small stream in Rush Township, Centre County. The water is of good quality, as shown by analysis A. Other places supplied with surface water include Casanova, Clearfield, Curwensville, Grass Flat, Hawk Run, Kylertown, Lanse, Osceola, Penfield, and Winburne. Records of eight public supplies using ground water are given below. In addition it is reported that about 200 people in Bell Township are supplied with spring water by the Rocky Springs Water Co., and that some spring water is used by Lumber City, in addition to water from the river.

Ansonville is supplied by the village from several small springs in the lower part of the Conemaugh formation. The water is distributed by gravity from a 15,000-gallon reservoir. About 150 people are supplied, and the water does not require treatment.

Part of Burnside (population 350) is supplied by the Burnside Mutual Water Co. from two small springs in the Mahoning sandstone on a hill southeast of the borough. The water is stored in two concrete reservoirs holding 100 and 4,000 gallons, and is

distributed by gravity to 8 families, 1 bank, and 1 school. The rest of the homes are supplied chiefly from private dug wells 12 to 28 feet deep and by three or four drilled wells.

Coalport (population 1,222) is supplied by the borough from two drilled wells (nos. 87 and 88). The turbine pumps in the wells discharge the water through an aerator, after which the water is treated, chlorinated, filtered, and pumped through the mains to the reservoir by two centrifugal booster pumps, each having a capacity of 80 gallons a minute. The treatment for removal of iron and softening is described on pages 72, 73, and the quality of water before and after treatment is shown by analyses 87a, b, and c. The reservoir, which is made of concrete and holds 100,000 gallons, is on a hill east of the borough. The average daily consumption is about 50,000 gallons. There are 40 fire hydrants. The maximum pressure is about 80 pounds to the square inch.

Eight homes and a hotel in Grampian (population 533) are supplied by gravity from a small hillside spring owned by Fred Snyder, and it is reported that two other groups of homes are supplied from two similar springs. The waters do not require treatment.

Helvetia is supplied from one drilled well (no. 61) by the Rochester & Pittsburg Coal Co. The well pump boosts the water to a reservoir from which it is distributed by gravity without treatment to 155 homes.

In Mahaffey (population 667) 25 families are supplied from three small springs owned by S. C. Mahaffey. The springs, which are on the hills east of the borough, discharge into one large and two small reservoirs, and the water is distributed by gravity without treatment. The supply is reported to be inadequate in dry weather.

West Decatur (Blue Ball) is supplied by the General Refractories Co. from two springs that issue from the Homewood sandstone west of the company's plant. The yield of Morrow Spring is reported to range from 25,000 to 300,000 gallons a day, and that of Straw Spring from 25,000 to 200,000 gallons a day. The water is stored in a 15,000-gallon concrete reservoir and is distributed by gravity to 30 homes and the refractory plant, which uses about one-fourth of the water. Chloride of lime is added to the water.

In Woodland 25 homes are supplied from spring 45 by the Harbison-Walker Refractories Co., Inc. The water is pumped to a small reservoir and distributed by gravity.

Typical wells and springs in Clearfield County

No. on pl. 2	Location	Owner or name	Topographic situation	Altitude (feet) ^a	Type of supply ^b	Depth (feet)	Diameter (inches)	Principal water-bearing bed				Length of casing (feet)	Depth to water level (feet)	Method of lift ^c	Yield (gallons a minute)	Use of water ^f	Remarks
								Depth to top of bed (feet) ^c	Thickness (feet)	Character of material ^d	Geologic horizon						
1	Sandy Township 0.2 mile east of Falls Creek	Henry Forsey.....	Valley	1,400	Dr	(?)	8	(?)	?	(?)	Allegheny or Pottsville	(?)	+	F	40±	N	Well filled with stones so that depth cannot be measured. Yield esti- mated. Water contains excess iron. Tempera- ture 50° F.
2	0.3 mile northwest of Du Bois	John Fye.....	Ridge	1,550	Dr	168	6	160	8	Black shale.	Below Upper Kittanning coal	144	133±	H	18±	D	Reported caved through Upper Kittanning coal and mine-out Lower freepport coal.
3	0.1 mile northwest of Du Bois	Adrian Furnace...	Valley	1,420	Dr	300±	(?)	(?)	?	Sandstone?	Pottsville.....	(?)	(?)	N	400±	N	Water reported saline.
4	Du Bois.....	City of Du Bois...	do.	1,400	DD	186	(?)	183	3	Gray ss....	Lower Alle- gheny	76+	(?)	N	?	N	Wells 4, 5, and 6 are drilled below the bottom of a 12 by 12-foot shaft, 76 feet deep. See log.
5	do.	do.	do.	1,400	DD	200	(?)	183	3	do.	do.	76+	(?)	N	?	N	Prior to 1900 the 3 wells adequately supplied a population of 9,500 with good water.
6	do.	do.	do.	1,400	DD	286	(?)	223	57	Gray and dark ss.	Allegheny or Pottsville	76+	(?)	N	?	N	
7	do.	Associated Gas & Electric Co.	do.	1,400	Dr	165	8	(?)	(?)	Sandstone...	Lower Alle- gheny	60	10±	N	200±	N	Wells 7 and 8 were used from 1915 to about 1918 but are now filled up. Water reported hard, saline, and acid. Wells were pumped by air lift. Cased through 60 feet of gravel and mud.
8	do.	do.	do.	1,400	Dr	204	10	(?)	(?)	do.	do.	60	6±	N	400±	N	Large yield reported.
9	do.	Du Bois Brewing Co.	do.	1,410	Dr	56	8	(?)	(?)	Slate?.....	Conemaugh or Allegheny	56±	(?)	S	(?)	C	Water reported to con- tain excess iron.

10	do.	do.	do.	Dr	50	8	(?)	(?)	(?)	do.	do.	50	(?)	A	(?)	(?)	Formerly 305 feet deep, but water was saline. Filled with concrete except for 50 feet. Reported large yield of good water, but used only in emergencies.
11	do.	do.	do.	Dr	175	8	(?)	(?)	(?)	Sandstone?	Clarion ss. . . .	100	2	F.A	(?)	I	Reported large yield of good water, but used only in emergency. Has been used as auxiliary city supply. When not being pumped water flows into pit below ground. Use 2 dug wells 30 and 40 feet deep, 30 feet in diameter, for water to make ice. Dug wells end in gravel.
12	do.	do.	do.	Dr	112	10	(?)	(?)	(?)	Sandstone.	Mahoning sandstone	80	1±	P	50±	C.I	Reported to flow occasionally. Leaves white centers in ice cakes. See analysis.
13	1.0 mile south of Du Bois	do.	do.	Dr	210	8	(?)	(?)	(?)	do.	Allegheny	8	185±	P	20±	D	Driller's location not checked.
14	West Liberty	Northwest Mining & Exchange Co.	Hilltop	Dr	535	(?)	.....	.....	.....	.....	.....	(?)	(?)	.....	.....	.....	Diamond-drill test for coal. See log. No record kept of water encountered.
15	0.5 mile northeast of West Liberty	Gus Heverling	Canyon	Dr	138	6	?	(?)	(?)	Sandy shale	Allegheny	20	98±	P	30±	N	Driller's location not checked.
16	1.9 miles east of West Liberty	Clyde Askey	Slope	Dr	120	6	100	20	(?)	Gray shale..	do.	35	70±	H	18±	D	Do.
17	0.5 mile south of Erion	Northwest Mining & Exchange Co.	Valley	Dr	390	(?)	(?)	(?)	(?)	?	Pottsville. . . .	200±	?	P	40	N	Formerly supplied 150 houses, but houses and well abandoned. Water reported to contain hydrogen sulphide and excess iron. Cased through open mine workings, and casing corroded through.
18	Shaffer.	George Coughlin . . .	do.	Dr	100	6	(?)	(?)	(?)	Sandstone?	Mahoning ss. . .	15	40±	H	18±	D	Reported small draw-down.
19	Sabula.	Pennsylvania Railroad Co.	do.	Dr	75	6	NB	(?)	(?)	Black shale.	Conemaugh. . . .	25	25±	H	20±	D	Do.
20	0.1 mile northeast of Sabula	Dr. Beal.	Hillside	Dr	120	8	105	15?	(?)	Sandstone..	do.	80	40±	P	10+	D	Cased through weathered shale.

* Altitude from Northwest Mining & Exchange Co.

Typical wells and springs in Clearfield County—Continued

No. on pl. 2	Location	Owner or name	Topographic situation	Altitude (feet) *	Type of supply *	Depth (feet)	Diameter (inches)	Principal water-bearing bed				Length of casing (feet)	Depth to water level (feet)	Method of lift *	Yield (gallons a minute)	Use of water †	Remarks
								Depth to top of bed (feet) *	Thickness (feet)	Character of material *	Geologic horizon						
21	Houston Township Hollywood.....	Shawmut Mining Co.	Valley	1,230	7 Dr	120	6	NB	(?)	Shale.....	Allegheny....	60	30±	H	5±	D	Seven wells in a row, all similar. Reported adequate supply. Considerable sand and gravel cased.
22	Tyler.....	Buffalo & Susquehanna Coal & Coke Co.	do.	1,220	Dr	40	6	(?)	(?)	(?)	do.	(?)	(?)	N	(?)	N	Water reported to be acid and to contain excess iron.
23	Union Township 0.9 mile southeast of Narrows Creek	John Du Bois estate	Slope	1,470±	Dr	580	6	180	(?)	(?)	Conemaugh or Allegheny	(?)	+11±	F	(?)	N	Test for coal. Reported large flow.
24	1.3 miles southeast of Narrows Creek	Cal Hoover (former owner)	Canyon	1,480±	Dr	80	6	30	50	Gray shale..	Allegheny Conemaugh...	(?)	+0.1±	F	(?)	N	Do.
25	1.2 miles north of Homecamp	Fred Weber.....	Hillside	1,790	Dr	78	10	NB	(?)	Shale.....	do.	22	37	N	1-3	D	Pump to be installed.
26	Rockton.....	Wilber Kirk.....	do.	1,740	Dr	85	8	20	65	Sandstone..	Clarion or Homewood sandstone	20	20±	P	5	D	
27	Pine Township 0.3 mile northwest of Smith Fire Tower	Clark Camp.....	Upland	2,150	Dr	90	6	NB	(?)	do.	Pottsville.....	15	15±	H	5±	D	Driller's location not checked.
28	Lawrence Twp. Clearfield....	Elk Tanning Co....	Valley	1,110	DD	170	8	(?)	(?)	(?)	do.	24±	26	S	85±	I	Pump in bottom of 24-foot pit. Water reported to contain excess iron. Reported 20-foot draw-down.
29	do.	New York Central R. R. do.	do.	1,100	Dr	150	6	140	10	Black slate.	do.	26½	20	S	100±	N	Well plugged. Reported excess iron. See log.
30	do.		do.	1,100	Dr	150	10	140	10	do.	do.	22	12	S	375±	R	No excess iron reported. See log.

31	Hyde.....	American Mond Nickel Co.	do.	1,100	Dr	107	12	NB	(7)	Soft gray sandstone	do.	50	+10±	S	300	(C)N	Plant shut down when visited in 1934. Well flows about 40 gallons a minute. Reported pumped at 832 gallons a minute with 25-foot draw-down after 8 hours' pumping. Water con- tains excess iron and re- ported unfit for boilers. Also have an 8-inch flowing well.
32	Dimeling	G. Root...	do.	1,160	Du	16	(7)	NB	(7)	Sand and gravel	Recent.	16	6.8 to 15	N	(7)	N	Well between Clearfield and Little Clearfield Creeks, about 100 feet from each. U. S. Geo- logical Survey observa- tion well, discontinued August, 1936; see pp. 35- 39.
33	Girard Township 0.2 mile east of Walton	New York Central R. R.	do.	1,160	Dr	60	6	26	34	Whites s...	Pottsville	26	20±	H	(?)	D	Water used but reported of poor quality.
34	Karhaus Township 0.2 mile east of Mowry	do.	do.	940	Dr	90	6	80	10	Light sandstone	Pocono...	36.5	20±	S	80-90	R	Reported draw-down 4 feet at 80 to 90 gallons a minute. Reported tested at 200 gallons a minute for 10 hours. Water satisfactory for loco- motive boilers. See log.
35	1.0 mile northeast of Cataract	do.	do.	800	Dr	55	6	42	13	Sandstone...	Pottsville?	42	26±	H	(?)	D	
36	Cooper Township	do.	Canyon	1,360	Dr	245	8	(7)	(7)	(7)	Pottsville	(7)	?	P	20	R	Large draw-down. Used only in emergencies.
37	0.3 mile west of Viaduct	do.	do.	1,360	Dr	240	6	(7)	(7)	(7)	do.	(7)	?	P	20	R	Do.
38	0.3 mile west of Kylertown	United Airlines, Inc.	Hillside	1,620	Sp					Shale	Allegheny.....			F	5±	D	Pneumatic pump system, supplies airport and one home.
39	Bradford Township	New York Central R. R. (former owner)	Valley	1,180	Dr	70	6	46	24	Whites s....	Pottsville.....	46	40±	H	5±	N	Abandoned; house sold.
40	0.5 mile south of Bishton	G. W. Jurry...	Hilltop	1,620	Dr	102	6	NB	(7)	(7)	Allegheny....	10	62	H	(?)	D, S, Ir	Owner also has spring and dug well.
41	Barrett	John Amy...	Hillside	1,280	Dr	120	6	(7)	(7)	(7)	Pottsville.....	(7)	?	P	(?)	D	Water reported to be unfit for drinking and to con- tain excess iron.

Typical wells and springs in Clearfield County—Continued

No. on pl. 2	Location	Owner or name	Topographic situation	Altitude (feet) ^a	Type of supply ^b	Depth (feet)	Diameter (inches)	Principal water-bearing bed				Length of casing (feet)	Depth to water level (feet)	Method of lift ^c	Yield (gallons a minute)	Use of water ^f	Remarks
								Depth to top of bed (feet) ^e	Thickness (feet)	Character of material ^d	Geological horizon						
42	Barrett.....	Harbison-Walker Co., Inc.	Hillside	1,280	Dr	145	6	(?)	(?)	Sandstone..	Pottsville.....	(?)	?	P	?	N	Formerly supplied 24 houses.
43	0.4 mile south of Barrett	do.	Slope	1,250	Dr	126	6	NB	(?)	Gray ss.....	do.	20	35±	P	80±	N	Formerly industrial use; not used because of poor quality. Excess iron re- ported.
44	Woodland (Mineral Spring)	Harbison-Walker Co., Inc., Mineral Spring	Valley	1,370	Sp	.....	.....	.....	.....	Sandstone?	do.	.....	.....	F	40±	N	Water contains excess iron; considerable iron oxide deposited at outlet. Temperature 53°F. Yield estimated.
45	do.	Harbison-Walker Co., Inc.	do.	1,400	Sp	.....	.....	.....	.....	Sandstone..	do.	.....	.....	F	5-10	P	Supplies 25 homes. Water pumped to reservoir by small electric force pump, and distributed by gravity. Temperature 48°F. Yield estimated. Reported nearly dry in 1930.
46	Woodland..... Pike Township	B. Albright.....	Hillside	1,480	Dr	60	6	NB	(?)	do.	do.	28.5	20±	H	3±	D	Water reported good.
47	Northwest corner of township	U. S. Dept. of Com- merce (airplane landing)	Ridge	2,200	Dr	91	6	(?)	(?)	do.	do.	20	10±	H	5±	D	Clay reported beneath the sandstone.
48	do.	Greenwood Camp.	do.	2,200	Dr	50	6	(?)	(?)	do.	do.	(?)	10±	P	5±	D	Well drilled into aban- doned clay drift. Water accumulates in reservoir constructed beneath well. Several similar wells in same drift are 29 and 38 feet deep.
49	2 miles northeast of Gramplan	Mr. Herr.....	Hillside	1,700	Dr	86	6	(?)	(?)	Gray ss.....	do.	20	18±	H	5±	D	
50	do.	George Solly.....	do.	1,730	Dr	44	6	12	32	Sandstone..	Homewood sandstone	(?)	?	H	?	D	

51	0.4 mile southwest of Bridgeport	Cresson Brick Co.	do.	1,300±	Dr	145	6	(?)	(?)	do.	Mauch Chunk or Pocono Pottsville.....	25	20±	H	3-5	D	Driller's location not checked.
52	0.2 mile west of Curwensville	Robert Campbell..	do.	1,260±	Dr	91	6	80	11	White ss....	Pottsville.....	17	31±	H	1¼	D	Driller's location not checked. No excess iron reported.
53	Curwensville.....	Franklin Tanning Co.	Valley	1,140	Dr	162	6	NB	(?)	Sandstone..	Connoquenessing ss.	(?)	12±	S	100±	I	Some hydrogen sulphide but no excess iron reported.
54	0.9 mile east of Curwensville	Seth Bloom.....	do.	1,140	Dr	72	6	65	(?)	Gray sandstone	Homewood sandstone	14	30±	P	3±	D	Pumps dry in 10 minutes at 10 gallons a minute.
55	0.7 mile southeast of Curwensville	New York Central R. R.	do.	1,170	Dr	75	6	40	35	Sandstone..	do.	25	13±	S	100	R	Reported draw-down 4 or 5 feet at 100 gallons a minute. No excess iron reported. Water satisfactory for locomotive boilers.
56	0.6 mile northwest of Olanta	Sam Lash.....	Canyon	1,360±	Dr	45	6	(?)	(?)	do.	do?	(?)	4±	H	5+	D	Driller's location not checked.
57	Brady Township 0.3 mile north of Salem	Walker Baker...	Hillside	1,630	Dr	75	6	NB	(?)	Shale.....	Conemaugh....	7, 5	30±	H	10±	D	Nearby dug wells reach a perched water table.
58	0.7 mile northwest of Luthersburg	A. L. Prantz.....	Ridge	1,740	Dr	120	7	NB	(?)	do.	Allegheny....	10	95±	H	10±	D	
59	0.3 mile northwest of Luthersburg	Mr. Marshall....	do.	1,760	Dr	70	6	NB	(?)	do.	do.	20	32±	H	10±	D	
60	0.7 mile west of Luthersburg	(?)	do.	1,790	Dr	189	8	170	(?)	Black shale.	do.	48	149±	P	16±	D, S	
61	0.2 mile south of Helvetia	Rochester & Pittsburgh Coal Co.	Valley	1,420	Dr	350	6	NB	(?)	(?)	Pottsville.....	(?)	?	S	100±	P	Supplies 155 houses. Water reported hard, but contains no excess iron and very little hydrogen sulphide. Reported well drilled through a fault. Water stands near surface.
62	Troutville.....	H. L. London.....	Ridge	1,540	Dr	91.5	6	(?)	(?)	(?)	Allegheny....	(?)	60±	P	3-5	D	Water reported hard.
63	2.6 miles southeast of Luthersburg	Ralph Wingart....	Slope	1,920	Dr	110	8	NB	(?)	Shale.....	do.	32	26±	A	10±	D	
64	Bell Township McGees Mills.....	Mrs. G. Y. Halfpenny	Valley	1,300	Dr	96	6	NB	(?)	(?)	Pottsville.....	(?)	+1	F	6	D	Water used for cooling food. Several flowing wells in town, but water unsuited owing to excess iron and hydrogen sulphide. Most of town supplied by 3 hillside springs.
65	Mahaffey.....	New York Central R. R.	do.	1,280	Dr	80	6	(?)	(?)	(?)	Homewood sandstone	(?)	6	S	?	R	Water reported satisfactory for locomotive boilers.

Typical wells and springs in Clearfield County—Continued

No. on pl. 2	Location	Owner or name	Topographic situation	Altitude (feet) ^a	Type of supply ^b	Depth (feet)	Diameter (inches)	Principal water-bearing bed				Length of casing (feet)	Depth to water level (feet)	Method of lift ^c	Yield (gallons a minute)	Use of water ^d	Remarks
								Depth to top of bed (feet) ^e	Thickness (feet)	Character of material ^d	Geologic horizon						
66	Penn Township Grampian	Lester Stonebraker	Valley	1,540	DD	52	6	(?)	(?)	(?)	Lower Allegheny	40±	8±	S	6	D	Water reported to be hard and to contain excess iron.
67	do.	State Bank of Curwensville	do.	1,540	Dr	110	6	(?)	(?)	(?)	Pottsville	?	10±	S	?	D	Water reported to be hard and to contain excess iron. Unsuitable for drinking.
68	0.7 mile east of Grampian	Harbison-Walker Co., Inc.	Hillside	1,550	Dr	82	6	(?)	(?)	Shale	do.	22	30±	H	?	D	Driller's location not checked.
69	Lumber City	New York Central R. R.	Valley	1,180	Dr	50	6	45	5	Dark ss	do.	25 7	10±	S	70	R	
70	Boggs Township 0.2 mile north of Wallacetown	Union Coal Co.	Slope	1,720±	Dr	214	6	199	9	White ss	do.	11	9±	N	(?)	N	Test for coal. Well reported flowing at depth of 199 feet. See log. Driller's location not checked. Considerable water encountered.
71	1.0 mile east of Wallacetown	Joe Kiedrick	Hillside	1,800	Dr	108	6	(?)	(?)	Sandstone	Lower Allegheny	13	18±	H	5±	S, D	
72	West Decatur	General Refractories Co.	Valley	1,530	Dr	75	8	75	.....	do.	Pottsville	75	40±	H	(?)	N	Not used since public supply installed.
73	Morris Township Morristale	Morristale High School	Ridge	1,640	Dr	80	6	76	4	do.	Allegheny	40	50±	H	5±	D	
74	Oak Grove	George Robbins	do.	1,580	Dr	161	6	120	(?)	do.	Allegheny or Pottsville	22	100±	H	5±	D	
75	Knox Township 0.9 mile south of Osanauer	William Dunlap	Hillside	1,580	Dr	130	6	120	10	Gray ss	do.	10	118±	H	5±	D	Water reported good.
76	1.4 miles south of Faunce	New York Central R. R.	Valley	1,300	Dr	83	6	46	4	Conglomerate	Pocono	30.5	8±	S	100	R	Reported draw-down 15 feet at 100 gallons a minute. Water satisfactory for locomotive boilers.

		H. M. Meckley	Slope	1,240	Dr	30	6	NB	(?)	Sandstone . . .	Pottsville . . .	8±	16 to 20	N	(?)	N	U. S. Geological Survey observation well, see pp. 33-39.
77	Greenwood Twp. 0.5 mile southwest of Bower																
78	Burnside Township Dowler Junction . . .	New York Central R. R.	Valley	1,310	Dr	129	6	102	27	Dark sandstone	Clarion sandstone	30	8±	S	100	N	Formerly supplied locomotives, but abandoned because of high iron content. Draw-down 20 feet at 100 gallons a minute. See log.
79	Cherry Tree	do.	do.	1,360	Dr	50	8	NB	(?)	Sandstone . .	Lower Freeport coal± do.	41	15±	H	5±	D	At engine house.
80	do.	B. W. Hawes	do.	1,360	Dr	45	6	NB	(?)	do.	do.	12	10±	H	3±	D	Water reported good.
81	Chest Township 0.3 mile north of Westover	J. K. Mosser Leather Corporation	do.	1,340	Dr	175	8	NB	(?)	do.	Pottsville . .	?	6±	S	200±	I	Used only for emergency; surface water preferred for processes.
82	do.	do.	do.	1,340	Dr	175	6	NB	(?)	do.	do.	?	6±	S	50±	D	Temperature 53°F. See analysis.
83	Westover	H. F. Moore	do.	1,360	Dr	52	6	(?)	(?)	(?)	Allegheny or Pottsville	?	20±	I	5±	D	Well satisfactory, but owner uses a small spring.
84	1.2 miles south of McPherron School	C. Conley	Ridge	1,840	Sp	.....				Sandstone or sandy sh.	Mahoning (upper ss.)			F	5±	D	Yield fluctuates but reported never dry. Temperature 53°F. See analysis.
85	Beccaria Township Irvington	A. E. Kanarr	Hillside	1,500±	Dr	165	6	NB	(?)	Sandstone . .	Lower Pottsville	(?)	50	A	2	P	Supplies 15 houses. Reported to be deepest well in Irvington. Several hillside wells less than 100 feet deep, but most valley wells are dug. Temperature 54°F. See analysis.
86	do.	Hiram Swanks Sons, Inc.	Valley	1,380	Dr	85-95	8	NB	(?)	do.	Pottsville or Mau Chunk	(?)	12±	P	50±	I	Water reported to be hard and to contain hydrogen sulphide and possibly iron.
87	Coalport	Borough of Coalport	do.	1,400	Dr	100	8	NB	(?)	do.	Pottsville . . .	(?)	16	T	70	P	Depth to water level measured June 5, 1923. Draw-down about 1 foot after 18 hours. Wells 87 and 88 are 30 feet apart. Either well reported to yield 175 gallons a minute with 2½ feet draw-down. Water is treated. Temperature 52°F. See analysis and p. 72.

Typical wells and springs in Clearfield County—Continued

No. on pl. 2	Location	Owner or name	Topographic situation	Altitude (feet) ^a	Type of supply ^b	Depth (feet)	Diameter (inches)	Principal water-bearing bed				Length of casing (feet)	Depth to water level (feet)	Method of lift ^c	Yield (gallons a minute)	Use of water ^f	Remarks
								Depth to top of bed (feet) ^e	Thickness (feet)	Character of material ^d	Geologic horizon						
88	Coalport.	Borough of Coal- port	Valley	1,400	Dr	128	8	NB	(?)	Sandstone...	Pottsville....	(?)	16	T	70	P	Depth to water level meas- ured June 5, 1934. Same water and same yield as well 87.
89	1.6 miles southwest of Coalport	J. W. Miles.....	Hillside	1,760	Du	30.5	48±	NB	(?)	Shale.....	Mahoning (lower ss.)	30.5	9.5	H	1-3±	S	Depth to water level meas- ured June 22, 1934. House supplied by small spring. See analysis.
90	1.4 miles southwest of Coalport	J. E. Ginter.....	do.	1,640	Sp	.....	.....	.....	.....	do.	4± feet above Lower Free- port coal	.....	.....	F	10±	D	Yield varies with precipi- tation but reported never dry. Temperature 53°F. See analysis. Owner has four springs, along C, D, and E coals. Driller's location not checked.
91	Beccaria.....	Berwind-White Coal Co. do.	Valley	1,370±	Dr	110	6	100±	10±	do.	Below Lower Kittanning coal±	50	40±	P	5±	D	Driller's location not checked. Driller re- ported no water above A coal. Reported casing extends below Mercer coal.
92	0.7 mile south of Beccaria	do.	do.	1,400±	Dr	419	6-4 1/4	NB	(?)	Light shale.	Lower Potts- ville or Mau. Chunk	320	150±	P	(?)	I	
93	Gulich Township 0.2 miles southeast of Ramey	James Mines.....	Hilltop	1,710	DD	81	6	NB	(?)	Shale.....	Mahoning (upper ss.)	20±	50±	A	3	D, S	See analysis.
94	Janesville (Smith Mill post office)	John Morrow.....	Hillside	1,550	Dr	82	6	NB	(?)	do.	Below Upper Kittanning coal	5±	40±	H	3-5±	D	

^a Altitudes taken from nearest contour on topographic map unless otherwise indicated.^b Dr, drilled well; Du, dug well; DD, dug and drilled well; Sp, spring.^c NB, near bottom.^d Sh, shale; ss, sandstone.^e A, air lift; F, natural flow; H, lift pump, hand-operated; I, pitcher pump, hand-operated; N, none;

P, force pump, power-operated; S, suction pump, power-operated; T, turbine pump.

^f C, condensing or cooling; D, domestic; I, industrial; Ir, irrigation; N, none; P, public supply;

R, railroad; S, stock.

Analyses of ground and surface waters from Clearfield County

[Parts per million. Numbers at heads of columns refer to corresponding numbers in the preceding table and on pl. 2.]

	12	82	84	85	87 ^a	87 ^b	87 ^c	89	90	93	A
Silica (SiO ₂).....		8.4		7.6	6.4						4.8
Iron (Fe).....		2.6	0.11	.40	28	28	0.28	1.3	0.11	0.26	.11
Calcium (Ca).....	29	33	.11	33	75		.18	.18	6.0	7.9	1.7
Magnesium (Mg).....	7.7	7.6		9.8	29				2.6	5.6	.5
Sodium (Na).....		{	{	{	{		{				{
Potassium (K).....	* 33	57	* 8	5.0	51		* 132	* 9	* 3	* 5	1.1
Bicarbonate (HCO ₃).....	190	2.1		1.7	2.7						.6
Sulphate (SO ₄).....	* 7	175	14	150	134	136	†	14	14	10	5.0
Chloride (Cl).....	8.2	19	.6	9.2	260		271	.16	12	20	2.6
Fluoride (F).....	.2	58	6.0	2.5	31		30	3.0	1.4	7.0	1.1
Nitrate (NO ₃).....	1.0		38	.22	.05		.05	.66	7.0	18	.05
Total dissolved solids.....	* 180	269		140	566				* 39	* 68	17
Total hardness as CaCO ₃	* 104	* 114	39	* 123	* 306		57	.66	* 26	* 43	* 6.3
Date of collection (1934).....	June 22	June 20	June 20	June 22	June 19	June 19	June 19	June 22	June 19	June 22	June 22
Analyst.....	E. W. Lohr	W. L. Lamar	W. L. Lamar	W. L. Lamar	W. L. Lamar	W. L. Lamar	W. L. Lamar	W. L. Lamar	W. L. Lamar	W. L. Lamar	W. L. Lamar

^a Sample of raw well water.^b Sample collected after aeration.^c Sample collected after softening and filtration.^d By turbidity.^e Calculated.^f Hydroxide (OH) 1.4 parts; carbonate (CO₃) 8.9 parts.

A. Sample of surface water from reservoir of Ramey Water Co., on Mountain Branch, Rush Township, Centre County. Collected from tap in Ramey.

*Composite log of abandoned wells of the city of DuBois, drilled in
bottom of 12 by 12-foot shaft, 76 feet deep*

[Nos. 4, 5 and 6. Authority, city engineer.]

	Thickness (feet)	Depth (feet)
Clay loam.....	5	5
Gravel.....	35	40
Loose rock.....	10	50
Shale, hard (bottom of shaft at 76 feet).....	42	92
Sandstone, gray.....	4	96
Slate, black.....	6	102
Shale.....	15.5	117.5
Fire clay and shale.....	6	123.5
Shale.....	10.5	134
Sandstone, gray.....	4	138
Slate, black.....	45	183
Sandstone, gray (water-bearing) (bottom of well 4 at 186 feet).....	3	186
Slate, black (bottom of well 5 at 200 feet).....	14	200
Shale.....	23	223
Sandstone, dark	42	227
Sandstone, gray		269
Sandstone, dark and gray		280
Slate, black (bottom of well 6).....		286

*Log of diamond-drill hole 262 of
Northwest Mining & Exchange Co., West Liberty*

[No. 14. Authority, Mr. Nagel, engineer.]

	Thick- ness		Depth			Thick- ness		Depth	
	Ft.	in.	Ft.	in.		Ft.	in.	Ft.	in.
Surface.....	8		8		Shale dark, sandy.....	9		407	
Shale, light, sandy.....	13		21		Slate.....	1		408	
Shale, gray, sandy.....	50		71		Coal B.....	2	1	410	1
Shale, dark.....	11		82		Slate.....		3	410	4
Coal.....		2	82	2	Limestone.....	4		414	4
Shale, gray.....	10	10	93		Shale and fire clay.....	12		426	4
Slate, black.....	16		109		Shale, dark, sandy.....	22		448	4
Shale, sandy.....	37		145		Slate, black.....	20		468	4
Sandstone (Mahoning).....	163		309		Coal A'.....	2	3	470	7
Sandstone, trace of coal.....	14		323		Fire clay.....	6		476	7
Coal D.....	1	3	324	3	Shale, sandy.....	8		484	7
Slate.....		9	325		Slate, black.....	3		487	7
Shale, calcareous.....	12		337		Coal A.....		9	488	4
Shale, sandy.....	20		357		Shale, gray.....	10		494	4
Slate, gray.....	20		377		Shale, sandy.....	19	8	518	
Shale, sandy.....	21		398		Sandstone, hard (Homewood).....	18		535	

Log of wells of New York Central Railroad

[Authority, Bert Rowles, assistant supervisor of bridges and buildings, New York Central R. R.]

Well 29 at Clearfield	Thick- ness (feet)	Depth (feet)	Well 30 at Clearfield	Thick- ness (feet)	Depth (feet)
Surface.....	6.5	6.5	Surface fill.....	4	4
Sand, clay and gravel.....	19.5	26	Sand, clay and gravel.....	15	19
Sandstone, yellow, conglomeratic	30	56	Rock, yellow.....	37	56
Sandstone, white.....	46	102	Sandstone, white.....	46	102
Slate, black (water-bearing)....	48	150	Slate, black (water-bearing)...	48	150

No. 34, near Mowry	Thick- ness (feet)	Depth (feet)	No. 78, at Dowler Junction	Thick- ness (feet)	Depth (feet)
Surface.....	7	7	Clay.....	29	29
Shale, red.....	27	34	Slate, black.....	36	65
Sandstone, gray.....	17	51	Coal.....	1.5	66.5
Sandstone, brown.....	10	61	Clay, hard.....	4	70.5
Sandstone, gray.....	19	80	Coal.....	3	73.5
Sandstone, light (water-bearing)	10	90	Sandstone, gray.....	28.5	102
			Sandstone, dark.....	27	129

Log of test hole of Union Coal Co., near Wallaceton

[No. 70. Authority, I. A. Black, driller.]

	Thick- ness (feet)	Depth (feet)		Thick- ness (feet)	Depth (feet)
Surface.....	12	12	Shale, black.....	8	199
Sandstone.....	123	135	Sandstone, white, (water- bearing).....	9	208
Shale and black "rock".....	12	147	"Rock".....	6	214
Sandstone, white.....	44	191			

CLINTON COUNTY

Area 878 square miles. Population (1930) 32,319.

GEOGRAPHY

Clinton County, the northernmost county in the area, is rather sparsely populated, there being only about 37 inhabitants to the square mile, as against 215 for the State as a whole. Except for the fertile limestone valleys in the southeast end of the county, it is mostly mountainous and forested. More than half the population is concentrated in the boroughs of Avis, Flemington, Mill Hall, Renovo, and South Renovo, each of which contains more than 1,000 inhabitants, and in the city of Lock Haven, which in 1930 had 9,668 inhabitants. Lock Haven is highly industrialized, and the most important industry is paper manufacturing. The Federal census of 1929 credits the county with 66 manufacturing establishments each of whose products were valued at \$5,000 or more annually. Some flint clay and coal are mined in the northern and western parts of the county, although very few of the coal mines appear to be in operation. With only about 17 percent of its total land area under cultivation, most of which is in Nittany Valley, Clinton County ranks last in agricultural development among the 14 counties covered by this report. The New York Central Railroad and the Pennsylvania Railroad serve the county, and the Buck-Tail Trail, a scenic motor highway, follows the Susquehanna River.

The Allegheny Front traverses Clinton County just north of Lock Haven, so that the southern third of the county is in the Ridge and Valley province, and the northern two-thirds in the plateau province. Topographic maps have not been made of the northern half of the county, but in the southern half, for which they are available, the highest point is in Beech Creek Township, where the Allegheny Mountains rise to an altitude of 2,340 feet. In Lamar Township Riansares Mountain has an altitude of 2,293 feet. The West Branch of the Susquehanna River leaves the county near Jersey Shore at an altitude of 520 feet, the lowest point in the county. The maximum relief in the surveyed part of the county is therefore about 1,820 feet. The greatest local relief is found along the West Branch of the Susquehanna, which flows through a narrow gorge 1,000 feet deep in some places. Clinton County is drained entirely by this stream.

GEOLOGY

The rock formations exposed in Clinton County range in age from the undifferentiated Cambrian and Ordovician limestones and dolomites (oldest) in Nittany, Nippenose, and Sugar Valleys

to the Allegheny formation, of Pennsylvanian age (youngest), remnants of which are found capping the high plateau in the northern part of the county (pl. 1) In addition there are rather thick deposits of Pleistocene sand, gravel, and clay along the West Branch. The character and water-bearing properties of these formations are described in the first part of this report.

All the mountains south of Bald Eagle Valley are formed by Silurian rocks. The Devonian rocks crop out in Bald Eagle Valley. The high plateaus are formed largely by the resistant Pottsville formation. The Nittany anticline is the principal structural feature, and there are several other folds, all trending northeast.

GROUND WATER

The Pleistocene unconsolidated deposits along the West Branch of the Susquehanna are the most productive water-bearers in the county, although they have not been exploited to any great extent.

The most productive consolidated deposits in the county are the Cambrian and Ordovician limestones and dolomites in Sugar, Nippenose, and Nittany Valleys, the Silurian and Devonian limestones in Bald Eagle Valley, and the Pocono formation in the Renovo district. There are numerous large springs in Nittany and Sugar Valleys, including nos. 241, 244, 249, 250, and 255. (See pl. 13.)

North of the Allegheny Front there are a few wells along the West Branch and its larger tributaries and along the Coudersport pike, but most of this area is rugged and forested, and the scattered mountain camps and homes are supplied largely from small springs. At Revono and Gleasonston there are several industrial wells. South of the Allegheny Front domestic supplies are obtained largely from dug wells but in part from drilled wells and springs. The large limestone springs are utilized only for domestic and stock supplies. Most of the people in Lamar obtain water from cisterns. There are numerous industrial wells in Lock Haven and vicinity, used principally to furnish water for cooling or condensing.

Only two flowing wells were observed in Clinton County, nos. 227 and 232. There appear to be no areas in the county where strong flowing wells might be expected.

Analyses of five samples of water from wells and springs in Clinton County are tabulated below. Only one of the analyses (no. 232) shows more than 1 part per million of iron, but three samples contained more than 0.1 part. Salt water has been struck by a few deep wells along the West Branch of the Susquehanna

north of the Allegheny Front, notably at Gleasonton (no. 201), Keating (no. 212) and Hyner. However, there is an abundance of fresh ground water at shallow depths at most places along the West Branch, and in most places the salt water can be avoided.

PUBLIC SUPPLIES

The city of Lock Haven, the larger boroughs, and many smaller places are supplied by surface water, including Avis, Charlton, Dunnstown, Flemington, Greenburr, Lockport, Mill Hall, Rauchtown, Renovo, and Woolrich. During a dry period the Lock Haven City Water Co. drilled a well near Castanea (no. 226), but the well was abandoned because of its small yield. The Suburban Water Co., which supplies Mill Hall and nearby places, has one drilled well that can be used in emergencies (no. 217). Descriptions of the four public supplies using ground water follow.

Booneville is supplied by the Booneville Water Co. from two small springs that issue from the Oswego sandstone on Sugar Valley Mountain, to the north. The water is stored in a 4,500-gallon covered concrete reservoir and is distributed by gravity to 25 families. It does not require treatment.

In Clintondale 13 families are supplied from one small privately owned spring that issues from the Reedsville shale on the mountain to the southeast. The water flows into a 1,000-gallon steel tank and is distributed by gravity at a maximum pressure of 85 pounds to the square inch. It does not require treatment.

Loganton (population 264) is supplied by the borough from three small springs (no. 253) in the gap at the north end of the borough. The springs flow into a 48,000-gallon reservoir, whence the water is distributed by gravity. In July 1934 the reservoir was observed to overflow at the rate of about 10 gallons a minute. There are 15 fire hydrants in the system. As shown by analysis 253, the water is of good quality, and it is served without treatment.

Tylersville is supplied by the Tylersville Water Co. from one spring that issues from the Oswego sandstone or the Juniata formation in the gap to the south. The water is stored in a covered concrete reservoir holding about 1,800 gallons and is distributed by gravity to about 75 families. On July 25, 1934, the reservoir was observed to overflow at about 12 gallons a minute. The water does not require treatment.

Typical wells and springs in Clinton County

No. on pl. 2	Location	Owner or name	Topographic situation	Altitude (feet) ^a	Type of supply ^b	Depth (feet)	Diameter (inches)	Principal water-bearing bed				Length of casing (feet)	Depth to water level (feet)	Method of lift ^c	Yield (gallons a minute)	Use of water ^f	Remarks
								Depth to top of bed (feet) ^d	Thickness (feet)	Character of material ^d	Geologic horizon						
194	Chapman Twp. Renovo.....	Pennsylvania R. R.	Valley	.....	Dr	300±	8	(?)	(?)	Sandstone...	Pocono.....	(?)	?	T	60±	C	Water reported unsuited for ice. No excess iron reported.
195	do.	Renovo Coal & Ice Co.	do.	.....	Dr	110	6	90	(?)	Red ss....	do.	30	60±	P	50	C,I	Satisfactory for ice.
196	do.	Harvey Witmire....	Hillside	.....	Dr	211	6	NB	(?)	Red and gray shale and ss.	do.	51	88	P	2.7	D	Water reported good. Water level measured in 1933 by owner.
197	0.5 mile east of Renovo	Associated Gas & Electric Co.	Valley	.....	Dr	88	6	(?)	(?)	(?)	do.	80±	20±	P	10	D,I	Use soda ash for boiler. Temperature 52°F. See analysis.
198	Farwell.....	Preston Paul.....	do.	.....	Dr	61	6	61	(?)	Sand and gravel	Pleistocene...	61	35	P	5+	D	61 feet of sand and gravel cased, open finish. Reported small draw-down on bailing 20 gallons a minute for 20 minutes.
199	North Bend.....	Christopher Hanson	do.	.....	Dr	112	6	NB	(?)	Red shale...	Pocono or Catskill	65	25±	N	35±	N	Formerly supplied light plant. 65 feet of sand and gravel cased off; some water in gravel.
200	Gleasonston.....	J. K. Mosser Leather Corp.	do.	.....	Dr	140	8	(?)	(?)	do.	do.	38	35±	N	(?)	N	Large yield reported, but well abandoned because of excess iron in water, 38 feet of sand and gravel cased off.
201	do.	do.	do.	.....	Dr	450	10	(?)	(?)	Red and gray ss.	Catskill.....	64	11±	N	(?)	N	Large yield reported, but well abandoned because of salty water.
202	do.	do.	do.	.....	5 Dr	30-50	6	30-50	(?)	Sand and gravel	Pleistocene (?)	30-50	20±	S	100	D,I	Aggregate yield of 5 wells, all ending just above bedrock. Water reported satisfactory except for bad taste. Temperature 54°F. See analysis.

203	0.7 mile northeast of Hyner	William Hibbler...	Hillside	.....	Dr	70	6	70	(?)	Red and green ss.	Catskill,	14	45±	H	2.5	D	When bailed dry fills at rate of 2.5 gallons a minute.
204	Hyner.....	Miles Cummings, ..	Valley	.....	Dr	40.5	6	40.5	(?)	Gravel.....	Pleistocene...	40.5	25±	H	5+	D	40 feet of sand and gravel
205	do.	Pennsylvania R. R.	do.	.....	Dr	60±	6	40	20±	Red sandy shale	Catskill.....	40	35±	H	3-5	D	cased off.
206	2 miles southwest of Trout Run station	Edwin Summerson..	Ridge	.....	Dr	178	6	NB	(?)	Sandstone..	Pocono.....	6	30±	H	5±	D	In Lycoming County just across road from Clinton County.
207	Gallagher Twp.																
208	0.5 mile southeast of Hanceville do.	Mr. Jones.....	Ridge	.....	Dr	86	6	70	(?)	Dark ss.....	Pottsville.....	35	45±	H	5±	S	Reported never dry. Water reported good.
209	2.3 miles southeast of Hanceville	do.	do.	.....	Dr	76	6	NB	(?)	Sandstone..	do.	(?)	45±	H	3-5	D	Has been pumped dry.
210	4.2 miles southeast of Hanceville Noyes Township	Roy Springer.....	do.	.....	Dr	52	6	NB	(?)	do.	do.	(?)	23±	H	3-5	D	Water reported good.
211	Westport.....	C. H. Springer.....	do.	.....	Dr	81	6	NB	(?)	do.	do.	10	40±	H	3-5	D/S	Water reported good.
212	East Keating Twp.	Mr. Clendenen...	Valley	.....	Dr	84	6	70±	14±	do.	Pocono.....	70±	13±	S	5	D	Reported never dry.
213	1 mile south of Keating	New York Central R. R.	Valley	725	Dr	96	(?)	70	(?)	Red shale....	Pocono.....	44	20±	N	200	N	About 70 feet of sand and gravel cased off.
214	Bald Eagle Twp.	Homestead Dairy Co.	Valley	560	Du	30-40	48	NB	(?)	Limestone.	Helderberg...	30-40	8	S	20	C	Tested at 200 gallons a minute, but abandoned because water was salty.
215	0.2 mile west of Mill Hall	George H. Johnstonbaugh	do.	570	Dr	140	6	140	(?)	Channel in limestone	Cayuga.....	140	?	S	5	C	Small draw-down reported on pumping 20 gallons a minute continuously.
216	do.	Sheffield Farms, Inc.	do.	570	Dr	101	8	NB	(?)	do.	do.	90	5	S	50	C	Channeled limestone encountered about 10 feet below surface.
217	do.	Mill Hall Brick Works	do.	580	Du	18	216	(?)	(?)	Gravel.....	Pleistocene...	18	9	S	150	I	Reported tested at 800 gallons a minute with moderate draw-down. Temperature 54°F. See analysis.
218	do.	Suburban Water Co.	do.	580	Dr	482	8	NB	(?)	Limestone..	Cayuga.....	40±	75±	A	300	P	Reported small draw-down pumping 1,000 gallons a minute for 4 hours. Reported too hard for boiler.
219																	Auxiliary supply; used only in emergencies.

Typical wells and springs in Clinton County—Continued

No. on pl. 2	Location	Owner or name	Topographic situation	Altitude (feet) ^a	Type of supply ^b	Depth (feet)	Diameter (inches)	Principal water-bearing bed				Length of casing (feet)	Depth to water level (feet)	Method of lift ^c	Yield (gallons a minute)	Use of water ^f	Remarks
								Depth to top of bed (feet) ^e	Thickness (feet)	Character of material ^d	Geologic horizon						
Castanea Township																	
218	Lock Haven	Kistler Leather Co.	Valley	560	Du	30	120	(?)	(?)	Sand or gravel	Pleistocene . . .	30	10 ±	S	21.5	I	Reported draw-down 15 feet on pumping 21½ gallons a minute con- tinuously.
219	do.	do.	do.	560	Dr	550	8	(?)	(?)	Shale?	Hamilton or Marcellus	(?)	20 ±	N	12	N	Reported draw-down about 100 feet on pump- ing 12 gallons a minute for 620 hours. Aban- doned in 1929 because of excess iron. When drilled in 1915 water contained less than 2.5 parts per million of iron, but iron increased to 41 parts per million in 1925.
220	do.	Lock Haven Auto Co.	do.	550 ±	Dr	78	6	(?)	(?)	Black shale.	Marcellus . . .	(?)	26	P	16	I	Reported draw-down 24 feet at 16 gallons a min- ute. Water level meas- ured summer of 1933.
221	do.	Clinton Ice & Coal Co.	do.	550 ±	Dr	230	6	NB	(?)	Channel in limestone	Helderberg or Tonoloway	125	45 ±	T	150 ±	C	125 feet of sand and gravel cased off. Reported draw-down 5 to 10 feet at about 150 gallons a minute.
222	do.	F. L. Winners Packing Co.	do.	550 ±	Dr	223	6	NB	(?)	Black shale.	Cayuga?	90	?	P	45	N	Water reported to be hard and to contain hydrogen sulphide.
223	do.	do.	do.	550 ±	Dr	50-55	10	.....	.....	Sand and gravel	Pleistocene . . .	50-55	?	S	80	N	Open finish; forced in truckload of gravel. Well caved in when dyna- mited to increase yield.
224	do.	American Aniline Products Co.	do.	550 ±	Dr	255	8	NB	(?)	Channel in limestone	Cayuga.	150	32 ±	T	550	Fr	Reported draw-down 4 feet on pumping 550 gallons a minute for 24 hours.
225	do.	Fairview Dairy	Slope	580	Dr	94	6	NB	(?)	Black shale	Marcellus or Cayuga	(?)	?	P	5-10	C	

226	0.3 mile southeast of Castanea	Lock Haven City Water Co.	Canyon	700	Dr	400	8	NB	(?)	Hard sh. and limestone	Cayuga or Clinton	30	2.5	N	50	N	Drilled for auxiliary public supply but abandoned because of small yield. Reported draw-down 40 feet at 50 gallons a minute. Water level measured July 21, 1934. Flows a small amount in the spring. No increase in yield below 50 feet. Dynamited at bottom without increasing yield.
227	do.	Castanea Ice & Beverage Co.	do.	700	Dr	360	6	50	(?)	Tight shale	do.	50	+ to 16	S	10	N	
228	Woodward Twp.																
229	Lockport	Lockport Brewing Co.	Canyon	580	Dr	262	6	(?)	(?)	Shale	Portage	(?)	12±	P	(?)	N	Reported adequate yield, but water too hard. On Great Island.
229	0.9 mile east of Lock Haven	Mr. Ronig	Valley	550±	Dr	41	6	41	(?)	Sand and fine gravel	Pleistocene	41	12±	H	5+	D	
230	do.	Mr. Ronig	do.	540	Dr	76	6	72	4	Gravel	do.	72	24±	H	5+	D	On Great Island. Reported small draw-down on pumping 25 gallons a minute.
231	Dunnstable Twp.																
231	0.7 mile southwest of Woolrich	Albert Maurer	Canyon	700	Dr	64	6	(?)	(?)	Shale	Chemung	(?)	15±	H	2	D	
232	Pine Creek Twp.																
232	0.3 mile west of Jersey Shore	A. K. Bobst	Valley	540	Dr	16	8	16	(?)	Gravel	Pleistocene	16	+1±	S	33	C.I	5 or 6 feet above Pine Creek. Flows a small amount. Water filtered for ice, owing to excess iron. See analysis. Water reported hard. Abandoned because of contaminated water.
233	do.	A. K. Bobst	do.	550±	Dr	275	6	57	(?)	Black shale	Marcellus	35.5	20±	S	5+	N	
234	0.3 mile southeast of Avis	New York Central R. R.	do.	550±	Dr	100	10	(?)	(?)	Limestone	Helberberg or Tonoloway	(?)	(?)	A	500	N	
235	Wayne Township																
235	Pine Station	Pennsylvania R. R.	Slope	570	Dr	60	6	60	(?)	Sand and gravel	Pleistocene	60	30±	H	5±	D	Clay, boulders, sand, and gravel penetrated. Do.
236	0.3 mile southeast of McElhattan	Mrs. Martha Fritz	Valley	610	Dr	60	6	60	(?)	Gravel	do.	60	30±	P	5+	D.S	
237	0.4 mile southeast of McElhattan	Col. H. W. Shoemaker	do.	620	DD	135	6	135	(?)	Gravel	do.	135	75±	H	5±	D.S	Clay, boulders, sand, and gravel penetrated. Reported dry in summer of 1933.
238	0.3 mile east of Youngdale	Mr. Poorman	do.	620	Dr	39	6	39	(?)	do.	do.	39	?	H	5±	D	

Typical wells and springs in Clinton County—Continued

No. on pl. 2	Location	Owner or name	Topographic situation	Altitude (feet) ^a	Type of supply ^b	Depth (feet)	Diameter (inches)	Principal water-bearing bed				Length of casing (feet)	Depth to water level (feet)	Method of lift ^c	Yield (gallons a minute)	Use of water ^f	Remarks
								Depth to top of bed (feet) ^e	Thickness (feet)	Character of material ^d	Geological horizon						
Lamar Township																	
239	1.9 miles northeast of Rote	Shuman Furst.....	Valley	800	Dr	84	6	NB	(?)	Crevice in limestone	Middle Ordovician	(?)	60	H	1-3	D	4-foot dry channel from 56 to 60 feet reported to take water from well. Draft of air reported to issue from dry channel. Reported draw-down 34 feet on pumping 13 gal- lons a minute for 1 hour. Issues from mouth of small cave in nearly horizontal beds of limestone. Water muddy after a rain. Yield estimated. Water joins much larger spring 0.1 mile south, in bed of intermittent stream. Both springs formerly used to run mill. (See pl. 13.)
240	Rote.....	Fred Nixon.....	do.	740	Dr	180	6	NB	(?)	do.	Lower or Middle Ordovician	20	12 ±	P	13	D	
241	0.3 mile east of Salona	Clyde Burrell, Big Spring	do.	640	Sp					Channel in limestone	Middle Ordovician			F	1,000 ±	N	
242	Salona.....	Mrs. Holloway.....	do.	620	Dr	42	6	NB	?	Limestone..	do.	(?)	?	P	3-5	D	Reported tested at 30 gal- lons a minute.
243	0.1 mile northeast of Cedar Springs	Mr. Fisher.....	do.	620	Dr	57	6	55	2	Channel in limestone	Middle Ordovician	20	12 ±	I	5+	D	Yield estimated July 25, 1934, when spring re- ported low. Reported dry 4 times during 14 years between 1904 and 1918; no data for other years. (See pl. 13.)
244	0.3 mile northwest of Mackeyville	W. H. Gardener...	do.	660	Sp					do.	Lower or Middle Ordovician			F	2,000 ±	D,S	
245	do.	do.	do.	660	Dr	50	6	NB	(?)	Limestone..	do.	(?)	12 ±	S	5 ±	D	
246	Porter Township 1.2 miles south of Parvin	Stanley Knecht	Hillside	870	Dr	302	6	302	(?)	Crevice in limestone	do.	20	200 ±	P	6	D,S	Some draw-down reported when pumped at more than 6 gallons a minute.

247	1.3 miles north of Clintondale	Calvin Royer	do.	880	Dr	160	6	160	(?)	do.	do.	Middle Ordovician	28	120±	P	6	D.S	Large yield reported.
248	1 mile northeast of Clintondale	Fred Nixon	Slope	760	Dr	125	6	123	2	Channel in limestone	do.	do.	10	60±	P	(?)	D.S	Issues from several places in bottom of large pool. Temperature 52°F. Water very clear. Yield estimated July 25, 1934, when spring was reported very low. Reported 3 or 4 times as strong in wet seasons.
249	1 mile south of Lamar	C. B. Gribbe	Valley	790	Sp						do.	do.			F	300±	D	Yield reported measured in fall of 1933. Temperature 56°F. Water very clear.
250	1 mile south of Lamar	U. S. Bureau of Fisheries, Steel Spring	do.	860	Sp						do.	do.			F	2,000±	P	Reported pumped dry in 20 minutes at 5 gallons a minute.
251	Greene Township																	
252	2.2 miles northwest of Rosecrans	E. D. McConnell	Ridge	1,700	DD	88	6	80	(?)	Sandstone	do.	Oswego	18	75±	P	5-	D.S	
253	1.5 miles northwest of Rosecrans	J. A. Seyler	do.	1,690	Dr	170	6	?	(?)	do.	do.	do.	(?)	50±	H	3-5	D	
253	Loganton	Borough of Loganton	Gap	1,400	3 Sp					Sandstone talus	do.	do.			F	20+	P	Oswego talus overlies Reedsville shale. Aggregate yield estimated. Temperature 53°F. See analysis of composite sample.
254	do.	E. E. Meyer, Sulphur Spring	do.	1,400	Sp					Shale	do.	Reedsville			F	2±	D	Roadside spring provided with house. Temperature 50°F. Water contains hydrogen sulphide. Two openings 400 feet apart, one dry and one low on July 30, 1934.
255	do.	John Kemmerer, Spring	Valley	1,210	Sp					Limestone	do.	Middle Ordovician			F	300±	D.S	Reported tested at 13 gallons a minute.
256	0.9 mile north of Carroll	Mr. Embick	Canyon	1,640	Dr	50	6	NB	(?)	Light ss	do.	Oswego	15	?	H	5±	D	
257	0.5 mile southwest of Carroll	George Schroyer	Slope	1,340	DD	105	6	NB	(?)	Limestone	do.	Middle Ordovician	(?)	?	H.P	3-5	D.S	
258	0.3 mile southeast of Carroll	do.	do.	1,330	DD	65	6	NB	(?)	do.	do.	do.	(?)	36±	H	5±	D	Moderate draw-down reported bailing 12 gallons a minute.

* Altitudes taken from nearest contour on topographic maps. No topographic maps of northern part of county.

^b Dr, drilled well; Du, dug well; DD, dug and drilled well; Sp, Spring.

* NB, near bottom.

^d Sh, shale; ss, sandstone.

^e A, air lift; F, natural flow; H, lift pump, hand-operated; I, pitcher pump, hand-operated; N, none; P, force pump, power-operated; S, suction pump, power-operated; T, turbine pump.

^f C, condensing or cooling; D, domestic; F, fish hatchery; Fr, fire protection; I, industrial; N, none; P, public supply; S, stock.

Analyses of ground waters from Clinton County

[Analyzed by E. W. Lohr. Parts per million. Numbers at heads of columns refer to corresponding numbers in the preceding table and on pl. 2.]

	197	202	215	232	253
Silica (SiO ₂).....			13		
Iron (Fe).....	0.14	0.31	.01	5.8	
Calcium (Ca).....	^a 20	^a 24	61	^a 20	^a 2
Magnesium (Mg).....			31		
Sodium (Na).....	} ^b 17	^b 57	{ 5.9	} ^b 12	^b 4
Potassium (K).....			{ 2.0		
Bicarbonate (HCO ₃).....	53	67	196	65	12
Sulphate (SO ₄).....	^a 7	^a 40	100	^a 14	^a 5
Chloride (Cl).....	35	72	14	24	.5
Fluoride (F).....	.0	.0	.0	.10	.0
Nitrate (NO ₃).....	.70	.30	3.3	.10	.30
Total dissolved solids.....	^b 111	^b 227	343	^b 113	^b 18
Total hardness as CaCO ₃	64	74	^b 280	74	8
Date of collection (1934)....	July 28	July 28	July 20	July 31	July 20

^a By turbidity.^b Calculated.

FULTON COUNTY

Area 403 square miles. Population (1930) 9,231.

GEOGRAPHY

Fulton County is the most sparsely populated county in the area, with only about 23 inhabitants to the square mile, as against 215 for the entire State. McConnellsburg, the largest borough in the county, had only 768 inhabitants in 1930. Except for a few coal mines in the Broad Top coal field, at the northwest corner, agriculture is the only industry in the county. Although Fulton County is very mountainous, about 65 percent of its total land area is under cultivation. The Federal census of 1929 credits the county with only 21 industrial establishments whose products were valued at \$5,000 or more annually. It is the only county in the area without a railroad (except for a coal spur that projects about a quarter of a mile across its northwest corner). The Lincoln Highway crosses the county and affords the principal route of travel.

The topography in Fulton County is typical of the Ridge and Valley province. Big Mount, on Tuscarora Mountain, rises to an altitude of 2,440 feet and is the highest point in the county. Other high points include Broad Top Mountain (2,390 feet), Sideling Hill, east of Emmaville (2,380 feet), and Bald Knob (2,301 feet). Great Tonoloway Creek crosses the State line at an altitude of 420 feet, the lowest point in the county. The maximum relief is therefore 2,020 feet.

The southern three-fourths of Fulton County is drained largely by tributaries of the Potomac River, including Sideling Hill, Great Tonoloway, and Licking Creeks. The northern one-fourth drains to the Juniata River through Aughwick Creek, and the valley in which Emmaville is situated drains through Brush Creek to the Raystown Branch of the Juniata.

GEOLOGY

The rock formations exposed in Fulton County range from the Beekmantown limestone, of Lower Ordovician age (oldest), to the Allegheny formation, of Pennsylvanian age (youngest). The oldest rocks are exposed only in Cove Creek Valley, in which McConnellsburg is situated. The youngest rocks crop out only in the Broad Top coal field, on Broad Top Mountain at the northwest corner of the county. By far the larger part of the county is underlain by Devonian rocks. The higher ridges along the eastern border are formed by the Tuscarora quartzite, and those elsewhere in the county are formed largely by the Pocono forma-

tion but in part by the Pottsville formation. The character and water-bearing properties of the different formations are described in the first part of this report. The folds trend northeast. The McConnellsburg and Little Scrub Ridge thrust faults cut out about 9,000 feet of strata along the west side of Cove Creek Valley, including all the Silurian and part of the Ordovician and Devonian.

GROUND WATER

Except for a group of springs that supplies the borough of McConnellsburg and one spring (no. 1111) that furnishes boiler feed water to a limestone quarry, all the wells and springs observed in Fulton County are used for domestic or stock supply. Thus the maximum water-yielding capacity of the different formations has not been tested. However, most of the formations appear to yield adequate supplies for domestic and stock use. Inasmuch as there are no railroads in the county it does not appear that large industrial water supplies will ever be developed. Dug wells are still in use in some parts of the county, but drilled wells or springs are believed to predominate.

Spring 1111, with an estimated yield of about 500 gallons a minute, is the only large spring observed in the county. Most of the others are small hillside springs that yield only a few gallons a minute.

Only one flowing well (no. 1105) was reported in the county. Flowing wells could probably be obtained in the valleys of Brush and Little Creeks and the Meadow Grounds, where the Pocono formation underlies the Mauch Chunk shale to form natural artesian basins, but probably large supplies will never be needed in either of these valleys.

The analyses of seven samples of ground water from as many geologic formations in Fulton County are given below. The waters analyzed are all rather low in dissolved solids, and 4 out of the 7 are relatively soft, the softest water having a hardness of only 16 parts per million (no. 1135, Pocono formation). None contained excess iron, but excess iron is reported in the water in many wells in the vicinity of Needmore, which tap the Marcellus shale. The water in the Ordovician limestones is only moderately hard (analysis 1111), but waters from limestones of the Cayuga group may be very hard, as they are in Bedford County. The quality of water to be expected in the different geologic formations is summarized on pages 80, 81.

McConnellsburg has the only public water supply in the county, furnished by the McConnellsburg Water Co. The water is obtained from 9 small springs along the Lincoln Highway on the slope of Cove Mountain. Most of the springs issue from the Juniata formation, but several issue from sandstones in the Martinsburg shale. Most of the springs discharge into the 66,000-gallon reservoir, from which the water is distributed by gravity. Water from the two lower springs (used only in emergencies) is pumped to the reservoir by a centrifugal pump with a capacity of 70 gallons a minute. Pressures range from 75 to 100 pounds to the square inch. About 1,200 people are served, including some people living outside the borough. The water is treated with chloride of lime, owing to the fact that all the springs are close to a well-traveled highway.

Typical wells and springs in Fulton County

No. on pl. 2	Location	Owner or name	Topographic situation	Altitude (feet) ^a	Type of supply ^b	Depth (feet)	Diameter (inches)	Principal water-bearing bed				Length of casing (feet)	Depth to water level (feet)	Method of lift ^c	Yield (gallons a minute)	Use of water ^d	Remarks
								Depth to top of bed (feet) ^e	Thickness (feet)	Character of material ^f	Geologic horizon						
	Wells Township																
1083	New Grenada....	John Houck.....	Valley	900	Dr	50-60	6	NB	(?)	Gray ss....	Pocono.....	15	30±	H	1-2±	D	Water reported to contain excess iron. Limestone overlain by red shale.
1084	0.6 mile northwest of Enid	Amon Edwards....	Hillside	1,140	Dr	35±	6	NB	(?)	Red shale....	Mauch Chunk	(?)	?	H	3±	D	
1085	1.2 miles northwest of Enid	Wrightly Bros.....	do.	1,260	Dr	105	6	NB	(?)	Gray ls....	do.	20	30±	H	3-5	D	
1086	0.7 mile northwest of Wells Tannery	Harry Helsel.....	do.	1,370	Dr	50	6	NB	(?)	Yellow sh....	do.	20	15±	H	3-5	D	
1087	Wells Tannery....	James Truax.....	do.	1,230	Dr	80	6	NB	(?)	Gray ls....	do.	30	40±	H	3-5	D	Do.
1088	1.1 miles southeast of Wells Tannery	Lambert Ford.....	do.	1,100	Dr	74	6	NB	(?)	Red ss....	do.	25	34±	H	3-5	S	
	Taylor Township																
1089	Waterfall.....	Tilman Newman	Valley	840	Dr	36	6	NB	(?)	Yellow ss....	Catskill.....	10	5±	H	3-5	D	
1090	0.3 mile west of Liram	Dave Hirshey.....	Hillside	1,180	Dr	75±	5	NB	(?)	Hard red sandstone	do.	(?)	45±	H	1-2	S	
1091	0.7 mile south of Liram	Ralph Berkstresser	do.	1,050	Dr	74	6	60	10	Gray ss	do.	20	45±	H	3-5	D,S	
1092	0.3 mile southwest of Laidig	William Anderson	Ridge	1,130	Dr	91	6	NB	(?)	do.	do.	22	65±	H	3-5	D,S	
1093	Hustontown....	Methodist Parsonage	do.	1,140	Dr	105	5	NB	(?)	Gray shale...	Chemung.....	20	25±	H	3-5	D	Formerly used for stock, but pump is broken. Very weak; no water below 30 feet. Also weak. Get most water from cistern and small spring.
1094	do.	Mrs. Bert Shaw....	do.	1,160	Dr	65	6	NB	(?)	Shale.....	do.	15	25±	H	3-5	D	
1095	1.6 miles southwest of Clear Ridge	Nate Stevens.....	do.	1,020	Dr	132	5	30	(?)	Brown ss....	Catskill.....	7	28±	H	1/6±	N	
1096	do.	do.	do.	1,030	Dr	100	5	(?)	(?)	do.	do.	8-10	50±	H	1±	D	
1097	1.5 miles southwest of Clear Ridge	Charles Brown....	do.	1,020	Dr	95±	6	NB	(?)	do.	do.	15	65±	H	1/3±	D,S	
1098	0.4 mile northwest of Clear Ridge	W. J. Henry.....	Hillside	1,060	Dr	180	6	NB	(?)	Blue ss....	Chemung.....	18	35±	H	3-5	D	

1099	Dublin Township 0.2 mile south of Fort Littleton	Lester Widel.....	do.	.....	Dr	66	6	NB	(?)	Red shale...	Bloomsburg...	12	34±	H	1-2	D	Some limestone near top. Temperature 53°F. See analysis.
1100	do.	Dublin Township Consolidated School	do.	.....	Dr	183	6	175	8	Limestone...	Cayuga.....	20	35±	P	7	D	Reported dry-down 35 feet at 7 gallons a min- ute. Some water at 30 and 105 feet.
1101	Todd Township Knobbsville.....	James Keebaw.....	do.	.....	Dr	70	6	NB	(?)	Blue shale...	Martinsburg...	30	30±	H	3-5	D	
1102	2.6 miles northeast of McConnellsb- urg	Fred Lamers.....	Slope	1,090	Dr	92	6	NB	(?)	Limestone...	Stones River...	53	46±	H	1-3	D	
1103	0.3 mile east of McConnellsb- urg	Fulton County Fair Association	do.	980	Dr	195	6	193	2	do.	Beekmantown	22	9±	P	6+	D,S	
1104	Ayr Township 0.3 mile south of McConnellsb- urg	Kenneth Glazier...	do.	900	Dr	62	6	62	(?)	Crevice in limestone	do.	18	38±	H	5±	D	
1105	2.5 miles west of McConnellsb- urg	Pennsylvania Dept. of Forests and waters	Valley	1,510	Dr	180	2	NB	(?)	Sandstone.	Mauch Chunk or Pocono	(?)	+1 or 2	F	1-2	N	Abandoned diamond-drill hole for coal.
1106	3.2 miles southwest of McConnellsb- urg	do.	do.	1,470	Dr	200±	2	NB	(?)	do.	do.	(?)	1 or 2	N	?	N	Do.
1107	1.6 miles southwest of McConnellsb- urg	Thomas.....	do.	820	Dr	60	6	50	5	Channel in limestone	Beekmantown	6-8	15±	H	5±	D	Well dynamited through numerous crevices.
1108	2.1 miles southwest of McConnellsb- urg	George Comer...	Hillside	920	Dr	124	6	NB	(?)	Shale.....	Portage?.....	20	24±	H	5±	D	
1109	0.8 mile north of Cito	George Ciders.....	do.	1,020	Dr	57	6	NB	(?)	Limestone...	Stones River...	30	40±	H	3-5	D,S	
1110	1.6 miles northeast of Webster's Mills	Henry Carbow...	do.	870	Dr	157	6	NB	(?)	do.	Beekmantown	20	127±	H,P	3	D	
1111	0.8 mile east of Big Cove Tannery	D. M. Morton, Big Spring	Valley	690	Sp	.....	.....	.....	.....	do.	Beekmantown or Stones River	.....	.....	F	500+	D,S I	Estimated aggregate yield from 5 openings. Tem- perature 53°F. See analysis.
1112	Big Cove Tannery.	Peter Kirk.....	Slope	650±	Dr	58	6	NB	(?)	Shale?.....	Onondaga or Mareellus	29	10±	H	3±	D	Reported dry, summer of 1932.
1113	0.8 mile northwest of Big Cove Tannery	Ralph Mollott....	Ridge	900	Dr	176	6	160+	(?)	Gray sandstone	Catskill or Chemung	24	60±	B	5±	D	
1114	1.5 miles west of Big Cove Tannery	A. T. Alban.....	Hillside	1,250±	Dr	85½	6	NB	(?)	Sandstone...	Pocono.....	40±	40±	H	3-5	D	

Typical wells and springs in Fulton County—Continued

No. on pl. 2	Location	Owner or name	Topographic situation	Altitude (feet) ^a	Type of supply ^b	Depth (feet)	Diameter (inches)	Principal water-bearing bed				Length of casing (feet)	Depth to water level (feet)	Method of lift ^c	Yield (gallons a minute)	Use of water ^f	Remarks
								Depth to top of bed (feet) ^e	Thickness (feet)	Character of material ^d	Geologic horizon						
	Licking Creek Twp.																
1115	0.5 mile northwest of Saluvia	Edward Kline.....	Hillside	1,190	Dr	72	5	NB	(?)	Red shale...	Catskill.....	16	?	H	3-5	D	
1116	Harrisonville.....	Howard Hollingshead	Valley	790	Dr	52	6	NB	(?)	Blue shale...	Chemung.....	30	3	S, I	4	D	Water reported hard.
1117	2.6 miles southwest of Andover	Will Swope.....	Hillside	960	Dr	71	5	NB	(?)	Red shale...	do.	20±	30±	H	3-5	S	
1118	2.8 miles southwest of Andover	Mrs. W. H. Roud-bush	do.	1,040	Dr	50	5	NB	(?)	Blue shale...	do.	20	20±	H	3-5	D	
	Belfast Township																
1119	1.6 miles north of Sipes Mill	Elias Hauman.....	do.	940	Dr	53	5	NB	(?)	Hard gray sandstone	do.	20±	15±	H	3±	D	
1120	0.6 mile southwest of Sipes Mill	Blaine Mellott.....	do.	870	Dr	88	5	NB	(?)	Red sandy shale	do.	25±	30±	H	3-5	D	
1121	0.4 mile southwest of Sipes Mill	Oliver Wilson.....	do.	840	Dr	45	6	30	0.1±	Hard blue shale	do.	30	30±	H	3-5	D	Do.
1122	3.1 miles northeast of Needmore	H. Kunz.....	Ridge	880	DD	60	6	NB	(?)	Blue shale...	Chemung or Portage	(?)	32±	H	3±	S	
1123	2.8 miles northeast of Needmore	Mrs. E. Truax.....	Canyon	780	Dr	30	6	NB	(?)	do.	Portage.....	(?)	3±	H	3±	D	
1124	2.3 miles northeast of Needmore	Maynard Deshong	Ridge	820	Dr	60	5	NB	(?)	do.	do.	25	25±	H	3-5	D	
1125	1.6 miles north of Needmore	Clem Lake.....	Valley	620	Dr	33	5	NB	(?)	do.	Hamilton.....	(?)	6 or 8	H	3-5	S	Well at house is 65 feet deep.
1126	2.0 miles northwest of Needmore	N. H. Deshong.....	Hillside	820	Dr	85	5	NB	(?)	do.	Portage or Chemung	20	30±	H	3-5	S	
1127	1.5 miles northwest of Needmore	Mason Mellott....	Canyon	700	Dr	42	5	NB	(?)	do.	Portage.....	15	10±	H	3±	D	
1128	1.1 miles west of Needmore	Charles Kirchener.	Ridge	820	Dr	90	5	NB	(?)	Yellow and gray shale	do.	20	30±	H	3-5	D	
1129	0.7 mile north of Needmore	Dr. J. J. Palmer...	Hillside	640	Dr	60	5	NB	(?)	Black shale.	Marcellus.....	20	10±	H	6	D	Water from most wells in Needmore reported to contain excess iron.
1130	0.9 mile northeast of Needmore	Claude Mellott....	Valley	600	Dr	30	6	NB	(?)	Blue sandy shale	Hamilton.....	12	10±	I	3±	D	

1131	Needmore	Belfast Township Consolidated School	Slope	640	Dr	80	6	NB	(?)	Black shale.	Marcellus	20	40±	P	10+	D	
1132	do.	Levi Garland ..	Valley	620	Dr	50	6	40	10	Limestone	Onondaga ..	20	S or 10	H	3-5	D	Temperature 55°F. See analysis.
1133	do.	Morgan Gordan ..	do.	590	Dr	59	5	NB	(?)	Blue-black shale	Marcellus	20	12±	H	3-5	D	
Brush Creek Twp.																	
1134	Bills-Place (Lin- coln Highway)	J. A. Strife	Saddle	1,940	Dr	125	6	NB	(?)	Dark sand- stone	Pocono	(?)	?	H	1±	N	Use cistern and small spring.
1135	Budd's Place (Lin- coln Highway)	Budd Myers	do.	2,190	Dr	175	6	NB	(?)	Blue shale ..	do.	20	30±	H	5+	D	Reported draw-down 45 feet at 20 gallons a min- ute. Temperature 50°F. See analysis. Have another well 85 feet deep.
1136	0.9 mile southwest of Akersville	Elmer Effland	Valley	1,200	Dr	65	6	NB	(?)	Red shale ..	Mauch Chunk	10±	15±	H	1-3	D	
1137	1.3 miles northeast of Crystal Spring	Jesse Barton	do.	1,190	Dr	70±	6	69±	1±	Red lime- stone	do.	12	?	H	1-2	D	
1138	Crystal Spring	Crystal Springs	do.	1,210	Sp					Red sand- stone	do.			F	1-2	D	
1139	Camp Grounds Emmaville	George Miller	do.	1,240	Dr	25	6	NB	(?)	Red shale ..	do.	8	2	H	15	D,S	Reported small draw- down.
1140	do.	Earl Truax	Slope	1,260	Dr	75	6	NB	(?)	do.	do.	10±	20±	P	1+	S	Temperature 52°F. See analysis. Limestone re- sembles Loyathanna; is burned for lime.
1141	0.5 mile southwest of Emmaville	Jake Spade	Hillside	1,320	Dr	52	6	50	1	Channel in siliceous limestone	do.	10 10	12	H	10±	D,S	
1142	0.6 mile northeast of Whips Cove	Howard Leighton ..	do.	1,100	Dr	65	6	NB	(?)	Red shale ..	Catskill	(?)	30±	H	3-5	D	
1143	Whips Cove	Carl Mellott	do.	1,040	Dr	60	6	NB	(?)	Hard brown shale	do.	8-10	38±	H	3-5	D	
1144	0.3 mile south of Whips Cove	Sherman Truax	do.	1,000	Dr	80	6	NB	(?)	Red and brown sh.	do.	8	25±	H	3-5	D	
1145	0.9 mile southeast of Whips Cove	Clom Smith	Valley	1,000	Dr	55	6	NB	(?)	Red sh. or sandstone	do.	20	20±	H	3-5	S	Temperature 54°F. See analysis.
1146	0.6 mile southeast of Whips Cove	Clarence Engle	Hillside	1,060	Dr	117	6	NB	(?)	Red shale ..	do.	8-10	35±	H	1-2	D	
Union Township																	
1147	0.8 mile west of Amaranth	George Carson	Ridge	1,100	DD	70±	6	NB	(?)	Red sand- stone	Catskill	(?)	?	H	3-5	D	
1148	0.6 mile south of Amaranth	George Ward	Hillside	950	Dr	135	6	NB	(?)	Red sandy shale	Chemung	(?)	?	H	3-5	D	
1149	1.0 mile southeast of Amaranth	Cecil Barnhardt ..	Ridge	1,020	Dr	70	6	NB	(?)	Yellow sandy sh.	Catskill or Chemung	8-10	48±	H	5±	D	
1150	0.6 mile west of Buck Valley	Lutheran Church ..	Hillside	1,060	Dr	118	6	NB	(?)	Brown sandstone	Chemung	40	30±	H	6-7	D	Reported draw-down 20 feet on pumping 6 or 7 gallons a minute.

Typical wells and springs in Fulton County—Continued

No. on pl. 2	Location	Owner or name	Topographic situation	Altitude (feet) ^a	Type of supply ^b	Depth (feet)	Diameter (inches)	Principal water-bearing bed				Length of casing (feet)	Depth to water level (feet)	Method of lift ^c	Yield (gallons a minute)	Use of water ^d	Remarks
								Depth to top of bed (feet) ^e	Thickness (feet)	Character of material ^d	Geologic horizon						
1151	Lashley.....	John Beatty.....	Ridge	1,030	Dr	86	5	NB	(?)	Red ss.....	Catskill.....	18	36±	H	6	D	Temperature 53°F. See analysis. Reported pumps dry in 1½ hours at 6 gallons a minute.
1152	2.5 miles west of Lashley	Mary Lee.....	Hillside	1,140	Dr	71	5	NB	(?)	Red shale...	do.	14	30±	H	½	D	
1153	0.7 mile south of Barnes Gap	Christina Smith...	do.	840	Dr	76	6	NB	(?)	do.	do.	20	38±	H	3-5	D	
1154	Bethel Township	S. P. Winter.....	Ridge	850	Dr	75	6	NB	(?)	Blue shale...	Chemung or Portage	(?)	25±	H	3±	D	
1155	0.6 mile northwest of Dott	Irene Hess and Bros.	Hillside	840	Dr	55	6	50	5	Channel in limestone	Helderberg...	30	45	H	10+	D	
1156	1.1 mile east of Dott	S. M. Carnel.....	do.	860	Dr	65	6	NB	(?)	Gray shale...	Portage.....	12	25±	H	6-	D	
1157	0.8 mile southwest of Dott	Nanny Spencer....	Ridge	850	Dr	80±	6	NB	(?)	Blue shale...	do.	(?)	40±	H	3±	D	Water reported soft. Sandstone dynamited but yield very small. Water hard but used in boiler. Reported draw-down 120 feet at 6 gallons a minute.
1158	1.1 miles southwest of Dott	Mrs. John Carnel..	do.	820	Dr	75	6	NB	(?)	do.	do.	(?)	40±	H	3±	D	
1159	3.3 miles northwest of Warfordsburg	Preston Smith.....	Hillside	640	Dr	68	6	NB	(?)	Gray sandstone	Chemung.....	16	48±	B	1-2	D	
1160	2.9 miles northwest of Warfordsburg	Sherman Garland...	do.	690	Dr	68	6	NB	(?)	Blue shale...	do.	12	15 to 30	H	3-5	D	
1161	2.1 miles northwest of Warfordsburg	Jacob Schultz.....	do.	740	Dr	120	5	80	40	Blue sandy shale	Portage.....	30	60±	W	6	D,S	
1162	2.9 miles northwest of Warfordsburg	P. O. Booth.....	do.	920	Dr	68	5	58	10	Hard brown sandstone	Catskill.....	14	48±	H	½	D,S	
1163	Warfordsburg.....	Bethel Township School	Slope	540	Dr	142	5	141±	1±	Channel in limestone	Wills Creek...	30	80±	P	11	D	Water reported to contain excess iron.
1164	1.3 miles south of Warfordsburg	Charles Manning...	do.	630	Dr	160	5	NB	(?)	Limestone...	Tonoloway...	30	30±	H	6-	D,S	
1165	Thompson Twp. 2.0 miles southwest of Sharpe	H. W. Hatfield.....	do.	600	Dr	42	6	NB	(?)	Black shale.	Marcellus.....	12	32±	H	3±	S	

1166	0.8 mile south of Sharpe	R. C. Gordan	Ridge	900	Dr	68	6	NB	(?)	Sandstone...	Chemung....	?	15±	B	2-3	D
1167	1.1 miles northwest of Diekeys Mountain	J. A. Kiefer	Hillside	640	Dr	81	5	NB	(?)	Hard brown sandstone	do.	10	40±	H	1	D, S
1168	0.9 mile north of Plum Run	Ray Weller	Ridge	860	Dr	52	5	NB	(?)	Blue shale...	do.	20	10±	H	3±	D, S
1169	Diekeys Mountain	L. O. Shives	Hillside	540	Dr	62	5	40	22	Shale.....	Hamilton(?)...	20±	20±	H	3±	D
1170	0.8 mile northeast of Plum Run	Mrs. Jonathan Snyder	do.	750	Dr	67	5	NB	(?)	Hard brown sandstone	Catskill.....	4	37±	H	1½	D
1171	0.8 mile southeast of Plum Run	George Winter	Ridge	800	Dr	102	5	NB	(?)	Hard yellow sandstone	do	15	47±	H	3±	D
1172	0.4 mile south of Plum Run	Oscar Liten	do.	820	Dr	120	5	110	10	Red sandy shale	do.	18	30±	W	6	D, S
1173	1.2 miles south of Plum Run	Ross Correll	do.	820	Dr	64	5	NB	(?)	Hard brown sandstone	do.	?	24±	H	3-5	D

^a Altitudes taken from nearest contour on topographic maps unless otherwise indicated. (No topographic map for northeast corner of county.)
^b Dr, drilled well; Du, dug well; DD, dug and drilled well; Sp, spring.
^c NB, near bottom.

^d Ls, limestone; sh, shale; ss, sandstone.

^e B, bucket; F, natural flow; H, lift pump, hand-operated; I, pitcher pump, hand-operated; N, None; P, force pump, power-operated; S, suction pump, power-operated; W, windmill.

^f D, domestic; I, industrial; N, none; S, stock.

Partial analyses of ground waters from Fulton County

[Analyzed by E. W. Lohr. Parts per million. Numbers at heads of columns refer to corresponding numbers in the preceding table and on pl. 2.]

	1099	1111	1133	1135	1141	1145	1156
Calcium (Ca) (by turbidity).....	65	65	30	2	18	14	1156
Sodium and potassium (Na+K) (calculated).....	9	3	10	2	3	7	5
Bicarbonate (HCO ₃).....	153	214	116	20	94	18	76
Sulphate (SO ₄).....	20	12	^a 60	^a 2	^a 4	^a 7	^a 4
Chloride (Cl).....	12	2.0	3.0	1.0	1	8.0	3.0
Nitrate (NO ₃).....	42	11	.30	.20	1.0	54	.0
Total dissolved solids (calculated).....	234	214	186	21	87	113	74
Total hardness as CaCO ₃	177	192	141	16	76	62	62
Date of collection (1933).....	Oct. 13	Oct. 13	Oct. 13	Oct. 13	Oct. 13	Oct. 13	Oct. 13

^a By turbidity.

HUNTINGDON COUNTY

Area 918 square miles. Population (1930) 39,021.

GEOGRAPHY

Huntingdon County is a mountainous, sparsely populated county having only 43 inhabitants to the square mile, as compared with 215 for the whole State. Huntingdon and Mount Union, with populations in 1930 of 7,558 and 4,892 respectively, are the only boroughs in the county with 1,000 or more inhabitants. Coal is mined in the Broad Top coal field, and glass sand, ganister, and limestone are quarried along the Juniata River. The Federal census of 1929 credits the county with 68 manufacturing establishments whose products were valued at \$5,000 or more annually. About 47 percent of the total land area of the county is devoted to agriculture. The main line of the Pennsylvania Railroad and the William Penn Highway follow the Juniata River across the county.

The topography is characteristic of the Ridge and Valley province. In addition to numerous long, narrow ridges there are two broad mountainous areas — the Seven Mountains, at the north end of the county, and Broad Top Mountain, at the south end. Big Flat, in Jackson Township, with an altitude of 2,400 feet, is the highest point in the county, and Broad, Grass, and Jacks Mountains all rise above 2,300 feet. The Juniata River leaves the county at an altitude of 520 feet, the lowest point in the county. The maximum relief is therefore 1,800 feet. Huntingdon County is drained entirely by the Juniata River.

GEOLOGY

The rocks exposed in Huntingdon County range from the Pleasant Hill limestone, of Middle Cambrian age (oldest), to the Conemaugh formation, of Pennsylvanian age (youngest). (See pl. 1.) In addition, thin fluvial deposits of Tertiary, Pleistocene, and Recent age are found along the Juniata River and some of its tributaries. The character and water-bearing properties of these formations are described in the first part of this report. The oldest rocks, the Cambrian and Ordovician limestones and dolomites, are exposed in the south end of Nittany Valley and in part in Kishacoquillas and Black Log Valleys. The Pennsylvanian rocks are exposed only on Broad Top Mountain. The Silurian rocks form long, narrow ridges in the eastern and western parts of the county and large mountainous areas in the northern part. The numerous folds trend northeast, and the most prominent ones are the Nittany anticline and the Broad Top syn-

cline. There are many faults in the northwestern part of the county.

The geologic structure of Huntingdon County is such that nearly all the geologic formations are exposed over wide areas in some part of the county, including most of the formations that generally crop out only in narrow, poorly exposed bands. Thus the Tuscarora quartzite and the Clinton formation are exposed over a large area in the Seven Mountains region, at the north end of the county, the Cayuga group forms a wide lowland belt south of the mountains; and the Helderberg limestone and Oriskany group are well exposed on the broad Warrior Ridge north of Huntingdon.

GROUND WATER

Domestic supplies at the farms and most of the villages in Huntingdon County are still obtained largely from dug wells, but small springs are also extensively utilized, particularly in some of the valleys that border high ridges. Practically all the water supplies in the Broad Top coal field come from dug wells. There are also numerous drilled wells in the county, and all the wells being put down at present are of this type. A few large limestone springs issue from the Cambrian-Ordovician rocks in the large valley in the northwestern part of the county, the largest of which is Hundred Springs (no. 546), with an aggregate yield from many openings of about 2,800 gallons a minute. All the water from this spring is pumped to Tyrone, in Blair County, where it is used in the manufacture of paper.

The Ridgeley sandstone and to a lesser extent the sandy Shriver chert crop out over large areas on Warrior Ridge, where they are weathered to a considerable depth by the removal of their calcareous cement. The resulting blanket of loose sand and disintegrated sandstone is so permeable that water falling as rain on the ridge sinks rapidly to the less permeable parts of the Shriver and Helderberg and emerges near the foot of the ridge as springs, such as springs 566, 570, and 591. The water table stands far beneath the surface on most parts of the ridge, making it necessary to case off thick beds of loose material before water is reached. Considerable difficulty was experienced in sinking wells 587 and 588, and no water was obtained in well 556. Similar conditions were found near Aughwick and Shirley, as shown by the records of wells 608 and 609. A view of the Ridgeley (Oriskany) sandstone in a glass-sand quarry at Mapleton is shown in plate 6, A.

The water from Warm Spring (no. 566), the largest spring observed to issue from the Ridgeley sandstone in Huntingdon County, has a temperature of 64°F., which is 13° warmer than that of the nearest spring (no. 570). It is possible that the water emerges along a concealed fault from a considerable depth, where the rock is known to have a higher temperature.

Most of the drilled wells that furnish industrial supplies are in towns along or close to the Juniata River, chiefly at Huntingdon (wells 572-576). Most of these wells in Huntingdon tap beds between the Hamilton formation and the Ridgeley sandstone, and three of them flow (no. 576). It is not improbable that additional flowing wells could be obtained in Huntingdon, especially from deeper wells that penetrate the Ridgeley sandstone.

The recovery curve of well 602 at Mount Union is shown in figure 10. The depth to water level was measured while the pump was running; then the pump was shut down, and the water level was measured at intervals for the ensuing 20 minutes. As indicated by the slope of the curve, the water level was still rising slowly at the end of this period.

The fluctuations of the water table in three observation wells in Huntingdon County (nos. 555, 568, and 599) and the precipitation at Huntingdon are shown in plate 9 and are discussed on pages 35-39. A view of well 555 is shown in plate 7, B.

In addition to the three flowing wells at Huntingdon noted above, records were obtained of only three other flowing wells in the county, (nos. 582, 610, and 632). It is doubtful whether additional flowing wells will be obtained in the vicinity of well 582. If additional flowing wells are found in the Broad Top coal field, the artesian head is likely to be small, as it is in well 632, owing to the fact that the outcrop area is not far above the discharge points at wells. As first pointed out by Butts,⁸⁹ there is an ideal artesian basin along the Broad Top syncline in Trough Creek Valley, where the Burgoon sandstone member of the Pocono underlies the Mauch Chunk shale and crops out in large catchment areas on both sides of the basin. Although flowing wells could probably be obtained here at depths of less than 1,000 feet, it appears unlikely that supplies of this type will ever be needed in Trough Creek Valley, which is devoted entirely to farming.

The analyses of 7 samples of ground water from as many geologic formations in Huntingdon County are given below. The

⁸⁹ Butts, Charles, U. S. Geol. Survey Geol. Atlas, Hollidaysburg-Huntingdon folio (no. 227) [in press].

samples from the Catskill, Ridgeley, and Mauch Chunk formations contained relatively small quantities of dissolved solids and were soft or moderately hard. Those from the Hamilton, Helderberg, and Wills Creek formations contained considerable dissolved matter and were very hard. It is not likely that all Hamilton waters are as hard as the sample from well 573, but some waters from the Helderberg and the Wills Creek are probably harder than those analyzed (nos. 589, 593). Only one sample contained iron in an objectionable amount—no. 610, from the Marcellus shale—but excess iron was reported in well 574. The quality of water to be expected from the other geologic formations is indicated on pages 80, 81.

PUBLIC SUPPLIES

Alexandria, Franklinville, Huntingdon, Mapleton Depot, Mount Union, Robertsedale, and Saltillo are supplied with surface water. It is reported that Mapleton Depot also has an auxiliary spring supply. The following places are supplied with ground water.

Blairs Mills is supplied by the Blairs Mills Water Co. from one small spring on the mountain to the east. The spring discharges into a 25-gallon stone reservoir, which is reported to overflow continuously, and the water is distributed by gravity at a pressure of about 75 pounds to the square inch. About 23 families are supplied, and at one time the now abandoned Tuscarora Valley Railroad was supplied. The water requires no treatment.

Orbisonia (population 741) and Rockhill (population 502) are supplied by the Orbisonia Water Co. from two small springs and one abandoned iron-ore tunnel on the slope of Black Log Mountain. The water is stored in a 5,600-gallon reservoir and is distributed by gravity at an average pressure of 45 pounds to the square inch. There are 4 fire hydrants in the system. About 264 families are supplied. The water does not require treatment.

The State Forest Nursery at Greenwood Furnace is supplied from springs, but no data were obtained concerning this supply.

The Pennsylvania Industrial Reformatory near Smithfield is supplied from spring 591. About 950 people use the water, and the average daily consumption is about 85,000 gallons. The water is of good quality, as shown by analysis 591, and is chlorinated.

Typical wells and springs in Huntingdon County

No. on pl. 2	Location	Owner or name	Topographic situation	Altitude (feet) ^a	Type of supply ^b	Depth (feet)	Diameter (inches)	Principal water-bearing bed				Length of casing (feet)	Depth to water level (feet)	Method of lift ^c	Yield (gallons a minute)	Use of water ^f	Remarks
								Depth to top of bed (feet) ^e	Thickness (feet)	Character of material ^d	Geological horizon						
Warriorsmark Twp.																	
541	Frogtown,	W. J. Keefer,	Valley	1,110	Dr	38	6	NB	(?)	Limestone...	Warrior?	(?)	24 ±	H	3-5	D	On or near a fault. Do.
542	0.9 mile northeast of Warriorsmark	Garman Bros. Club House	do.	1,110	Dr	70	6	NB	(?)	do.	do.	30	25 ±	H	3-5	D	
543	2.1 miles northeast of Nealmont	J. Cole,	Hillside	1,060	Dr	52	6	NB	(?)	Dolomite...	Bellefonte, ...	14	?	H	3-5	D, S	Aggregate yield of many springs in canyon meas- ured by owner.
544	1.5 miles northeast of Nealmont	G. Guyer,	Valley	1,000	Dr	99	6	NB	(?)	do.	do.	8	18 ±	P	4	D, S	
545	1.0 mile northeast of Nealmont	Tyrone Lime & Stone Co.	do.	970	Dr	50	6	NB	(?)	Limestone...	Lowville ±	42	0 to 10	S	250	D	Also has a 55-foot well with hand pump for stock.
546	0.5 mile northwest of Birmingham	West Virginia Pulp & Paper Co., Hundred Springs	Canyon	870 ±	Sp	.....	.....	.....	.....	Dolomite...	Bellefonte, ...	.....	.....	F	2,800 ±	I	
547	1.0 mile south of Warriorsmark	Neff Bros.	Hillside	1,150	Dr	160 ±	6	(?)	(?)	Limestone...	Warrior,	80	150	H	3-5	D	
548	0.3 miles south of Dungarvin	A. G. Garber,	Valley	1,110	Dr	65	6	(?)	(?)	Sandstone...	Gatesburg ...	65	8	P	5 ±	D	
Franklin Township																	
549	1.0 mile east of Graysville	Mr. McWilliams ...	Hillside	1,100	Du	42	48	NB	(?)	Dolomite...	Bellefonte, ...	42	38	B	2-3	D	Water level measured Sept. 5, 1933. Reported dry in summer of 1932. Equipped with hydraulic ram. Temperature 52°F. Flow estimated.
550	Graysville,	Mrs. Elder,	Valley	1,040	Sp	.....	.....	.....	.....	do.	Nittany, .....	.....	.....	F	500 ±	D, S	
551	0.9 mile northeast of Seven Stars	B. Behrs,	Slope	1,100	DD	43	6	NB	(?)	do.	do.	35	?	P	5 +	D	Reported small draw-down at 30 gallons a minute. Equipped with hydraulic ram. Temperature 54°F. Flow estimated.
552	Seven Stars,	Robert M. Wilson.	Canyon	1,030	Sp	.....	.....	.....	.....	do.	Bellefonte, ...	.....	.....	F	40 ±	D, S	
553	0.2 mile west of Huntingdon Furnace	Will Hicks,	Hillside	1,000	Dr	128	7	60	61	Slate?	Stonchenge, ...	121	58 ±	P	5 ±	D	Dolomite underlies the slate?

554	West Township 0.6 mile north of Neffs Mills	Dr. Luper.....	do.	900	Dr	108	6	(?)	(?)	Dark shale.	Lower Cayuga	?	?	H	3-5	D	U. S. Geological Survey observation well; see pp. 35-39 and pls. 7, B and 19. Dry hole. Limestone over- lain by 44 feet of sandy shale.
555	3.2 miles northeast of Petersburg	Mrs. A. Eborly.....	Valley	720	Du	8.8	48	(?)	(?)	Soil and shale	McKenzie.....	9.2	0 5 to 6	N	?	N	
556	2.1 miles southeast of Cottage	Oscar Hahn.....	Ridge	1,280	Dr	127	6	(?)	(?)	Limestone..	Oriskany.....	65	....	N	0	N
557	Barree Township Saulsburg.....	Ed Houck.....	Valley	830	Dr	24	6	NB	(?)	Black slate.	Upper Cayuga	18	5±	I	5	D	Reported tested at 30 gal- lons a minute with small draw-down. Well at barn is 57 feet deep.
558	Jackson Township 1.5 miles east of Charter Oak	Red Rose Rod & Gun Club	Hillside	980	Dr	43	6	NB	(?)	Green shale.	Cayuga or Clinton	19	18±	H	5+	D	
559	McAlevys Fort.....	H. J. George.....	do.	780	Dr	60	6	NB	(?)	Limestone..	Tonoloway....	8	35±	H	5±	D	
560	1.0 mile southwest of Ennisville	Frank Cunningham	Valley	740	Dr	40	6	NB	(?)	Black shale.	Heldberg.....	?	20±	H	3-5	D	Deepened from 80 feet. Nearby wells 80 feet deep supply enough for hand pumps. Water re- ported to be hard.
561	Brady Township 2.0 miles southwest of Allenville	Sam Metz.....	do.	910	Dr	44	6	(?)	(?)	Hard lime- stone	Lower or Middle Ordovician	12	6	P	9	D, S	
562	3.6 miles southwest of Allenville	Jesse Ellis.....	Hillside	1,000	Dr	55+	6	(?)	(?)	Limestone..	do.	12	5±	H	3-5	D	
563	Mill Creek.....	Ira Faust.....	do.	660	Dr	128	6	NB	(?)	Shale.....	Chemung.....	27	48±	P	5±	D	Temperature 54°F. See analysis.
564	Henderson Twp. 1.5 miles northwest of Mill Creek	Wright's Farm Market	Valley	610	Dr	150	6	NB	(?)	Red sand- stone	Catskill.....	23	20	P	5	D, S	
565	Ardenheim.....	William Kyler.....	do.	610	Dr	64	6	NB	(?)	Gray shale..	Chemung.....	25	25±	H	3-5	D	
566	Oneida Township 1.0 mile northwest of Center Union	Warm Spring.....	Hillside	660	Sp	Sandstone..	Ridgeley.....	F	750±	N	Temperature 64°F. Flow estimated. Small yield at 400 feet. Re- ported draw-down 35 feet on pumping 80 gal- lons a minute. U. S. Geological Survey observation well; see pl. 9 and pp. 35-39.
567	0.8 mile southwest of Center Union	J. R. Walds.....	do.	690	Dr	756	6	NB	(?)	Shale.....	Portage or Hamilton	20	26	P	80±	D	
568	1.0 mile southwest of Center Union	John B. Neal.....	do.	660	Du	26	24	NB	(?)	do.	Portage.....	26	5 to 14	N	(?)	N	
569	1.2 miles southwest of Center Union	do.	do.	640	Dr	44	6	NB	(?)	Black shale.	do.	20	12±	H	3-5	S	

Typical wells and springs in Huntingdon County—Continued

No. on pl. 2	Location	Owner or name	Topographic situation	Altitude (feet) ^a	Type of supply ^b	Depth (feet)	Diameter (inches)	Principal water-bearing bed				Length of casing (feet)	Depth to water level (feet)	Method of lift ^c	Yield (gallons a minute)	Use of water ^f	Remarks
								Depth to foot of bed (feet) ^e	Thickness (feet)	Character of material ^d	Geologic horizon						
570	2.0 miles southwest of Center Union	F. W. Zinn, Cold Springs	Hillside	700	Sp					Sandstone...	Ridgeley....	.....	...	F	140±	D	Reported aggregate yield of 12 springs close to- gether in a park. Tem- perature 51°F. Water reported soft.
571	0.8 mile northeast of Huntingdon	Edgar Lindsay....	do.	780	Dr	120	6	115	5	do.	do.	35	75±	P	7+	D	All sandstone; some water at 70 feet. Well yielded 12 gallons a minute in test. Water reported soft.
572	Huntingdon.....	Clifton Theater....	Valley	630	Dr	197	6	NB	(?)	Shale?.....	Hamilton....	(?)	1	S	90	C	Reported draw-down 4 feet. Water used to cool theater in summer. Temperature 56°F. See analysis. Pumped only 4 hours daily. Water contains hydrogen sul- phide.
573	do.	Supplee-Wills-Jones Milk Co.	do.	620	Dr	186	8	NB	(?)	(?)	do.	(?)	8±	T	300±(?)	C	Yielded 50 gallons a min- ute prior to 1931. Re- ported draw-down 20 feet. Temperature 54°F. Water contains excess iron; clogs condensers in 3 days.
574	do.	Steel Ice Co.....	do.	640	Dr	385	10	NB	(?)	(?)	Onondaga or Ridgeley	(?)	30	T	40	C	Two wells same depth; each yields 30 gallons a minute. Water contains hydrogen sulphide (H ₂ S) Aggregate yield of 3 wells connected to one pump. Reported draw-down 20 feet. Each well flows about 25 gallons a min- ute. Water makes clear ice. Wells penetrate en- tire Onondaga forma- tion. Water in fossil bed.
575	do.	Benson Bros. Ice Cream Co.	do.	660	2 Dr	136	4	NB	(?)	Slate..	Marcellus....	(?)	6 or 8	P	30	C	
576	do.	Boyle Ice Co.....	do.	620	3 Dr	184	8	NB	(?)	Limestone or ss.	Onondaga or Ridgeley	(?)	+1 or 2	S	120	C, I	

577	0.2 mile north of Huntingdon do.	Ed Foster	Hillside	760	Dr	115	6	NB	(?)	Sandstone	Ridgeley	2	100	H	5 ±	D
578		Pennsylvania R. R., Deer Tower	Valley	700	Dr	69	6	NB	(?)	(?)	Shriver	(?)	?	H	5 ±	D
579	Logan Township															
	Petersburg	Mr. Huston	Hillside	700	Dr	74	6	NB	(?)	Soft lime-stone	Wills Creek	25	30 ±	P	3-5	D
	Spruce Creek Twp.															
580	0.9 mile north of Pemberton	H. L. Orr	Ridge	1,090	Dr	350	6	(?)	(?)	Dolomite	Bellefonte	8	20 ±	P	1	D
581	Spruce Creek	Frank Palmer	Hillside	820	Dr	141	6	NB	(?)	do.	Nittany	26	40 ±	H	5 ±	D
582	0.7 mile south of Spruce Creek	Jesse Federhoof	do.	1,080	Dr	64	6	NB	(?)	do.	Bellefonte	(?)	+ 1 or 2	F	1 ±	D
	Morris Township															
583	0.4 mile southwest of Union Furnace	S. W. Londer	do.	870	Dr	40	6	(?)	(?)	Limestone	Trenton	(?)	12 ±	H	3-5	N
584	Shafersville	R. A. Norris	Canyon	780	Dr	25	6	NB	(?)	Dolomite	Bellefonte	(?)	20 ±	I	3-5	D
	Porter Township															
585	Alfarata	Stowe-Puller Re-fractories Co.	Valley	740	Dr	206	6	NB	(?)	?	Clinton	(?)	40 ±	P	17	I
586	0.7 mile south of Alexandria	J. W. Houck	do.	700	Dr	28	6	NB	(?)	Shale or limestone	Wills Creek	19	13	H	5 ±	D
587	2.5 miles northwest of Huntingdon	John Runk	Ridge	1,140	Dr	125	6	123	2	Limestone	Helderberg	30	80 ±	N	?	N
588	2.4 miles northwest of Huntingdon	do.	do.	1,080	Dr	317	4	277		do.	Helderberg?	317	277 ±	P	16	D, I, S
589	2.0 miles west of Huntingdon	D. A. Woods	do.	1,050	Dr	94	6	NB	(?)	do.	Helderberg	45	65	H	5	D
	Smithfield Township															
590	1.0 mile northwest of Smithfield	John W. McClain	Hillside	780	Dr	130	6	NB	(?)	Sandstone	Ridgeley	33 ±	98	H	5 +	D
591	0.6 mile west of Smithfield	Pennsylvania Industrial Refractory	Slope	660	Sp					do.	do.			F	60 +	P

Owner uses spring, but well is usable.

Used only when public supply of Alexandria is low. Water satisfactory for boiler.

Has 2 other wells 18 and 35 feet deep. Water reported hard.

No water reported in upper 123 feet of Shriver sandstone. Well filled with sand; insufficient casing. Clay (weathered Shriver) 60 feet; limestone, 217 feet; black shale, 40 feet. Lower 40 feet of casing perforated. Uses 1,500 gallons daily.

Cased through 45 feet of clay. Temperature 51°F. See analysis.

Water reported soft.

Use 85,000 gallons daily, supplies 950 inmates plus officers. See analysis.

Typical wells and springs in Huntingdon County—Continued

No. on pl. 2	Location	Owner or name	Topographic situation	Altitude (feet) ^a	Type of supply ^b	Depth (feet)	Diameter (inches)	Principal water-bearing bed				Length of casing (feet)	Depth to water level (feet)	Method of lift ^c	Yield (gallons a minute)	Use of water ^f	Remarks
								Depth to top of bed (feet) ^d	Thickness (feet)	Character of material ^e	Geologic horizon						
Walker Township																	
592	0.5 mile west of McConnellstown	Walter Thompson.	Valley	710	Dr	42	6	NB	(?)	Limestone...	Wills Creek...	20	12	S	5±	D	Well at barn about 35 feet deep, equipped with electric suction pump. See analysis.
593	1.5 miles north of Heston (Grafton)	H. Shafer.....	do.	770	Dr	31	6	NB	(?)	do.	do.	10	2 or 3	S	12	D	
594	1.4 miles north of Heston (Grafton)	W. R. Ward.....	do.	760	Dr	30	6	NB	(?)	do.	do.	5	4 or 5	I	3-5	D,S	Water reported hard.
Penn Township																	
595	Marklesburg (James Creek)	Borough School...	Hillside	900	Dr	50	6	(?)	(?)	Sandstone...	do.	20	20	N	?	N	Well filled with sand; in- sufficient casing.
596	do.	C. B. Boyer.....	Slope	860	DD	65±	6	NB	(?)	Limestone...	Tonoloway...	(?)	15±	S	3-5	D	Water hard; uses cistern for washing.
597	Aitch.....	Mrs. Auman.....	Valley	800	Dr	85	6	(?)	(?)	Dark shale.	Marcellus.....	(?)	20±	H	3-5	D	Water reported hard.
598	2.0 miles southeast of Aitch	Fred M. Schell.....	Slope	720	Dr	86	6	(?)	(?)	Red sand- stone	Chemung.....	46	45±	H	5±	D,S	
599	do.	do.	do.	720	Dr	42	6	NB	(?)	Sandstone...	do.	(?)	12 to 26	N	?	N	U. S. Geological Survey observation well; see pp. 35-39 and pl. 9.
Union Township																	
600	0.6 mile north of Mapleton Depot	Fred Hack.....	Valley	610	Dr	81	6	80	1	do.	Portage.....	28	15±	S	5	D	Reported draw-down 5 feet on pumping 28 gal- lons a minute for 15 minutes.
Shirley Township																	
601	Mount Union.....	M. Hansharanko.	do.	580	Dr	78	6	NB	(?)	Hard sand- stone	Cayuga.....	34	23±	H	5±	N	Tested at 28 gallons a min- ute. Owner uses city water.
602	do.	Mount Union Ice & Coal Co.	do.	580	Dr	106	6	93	13	Red shale...	Bloomsburg±	38	8	S	80±	C	Measured draw-down 6+ feet on pumping 80± gallons a minute. See fig. 10 and p. 55. Tem- perature 55°F.

	do.	do.	do.	580	Du	33	156	27	6	Hard sand- stone	Cayuga.....	33	s	S	?	C	
603	do.	do.	do.	580	Dr	33	6	NB	(?)	Dark shale.	Hamilton.....	30	15±	I	3-5	D	Another 27 foot dug well 8 feet away, connected by tunnel at base. Both wells pumped at 120 gallons a minute, but water is returned to wells. Temperature 54°F.
604	Allenton.....	Mrs. Burns.....	do.	580	Dr	72	6	NB	(?)	Dark shale.	Helderberg.....	30	15±	F	50±	D	Temperature 52°F. Yield estimated. Reported about 100 gallons a minute in wet seasons. Many springs along Hill Valley.
605	2.4 miles west of Aughwick	Mrs. M. F. Swope.	do.	700	Sp					Limestone.						D	Small yield in 1930.
606	2.5 miles northwest of Shirleysburg	T. L. Hancock.....	Slope	880	DD	115	6	NB	(?)	do.	Cayuga.....	(?)	?	H	3-5	D	Reported tested at 28 gallons a minute. Well satisfactory but not used.
607	0.7 mile northwest of Aughwick	Ira Gardener.....	do.	580	Dr	92	6	(?)	(?)	Dark shale.	Marcellus....	21	20±	N	5+	N	Well
608	Aughwick.....	Mrs. Wagner.....	Valley	570	Dr	90	6	85	5	Sandstone..	Oriskany....	85±	60±	H	5±	D	85 feet of loose sand cased.
609	Shirleysburg.....	Mrs. J. H. Meyers.	do.	580	Dr	76	6	64	12	do.	do.	64	15±	H	5+	D	64 feet of loose sand cased.
610	do.	Charles Terizzy...	Slope	600	Dr	55	6	NB	(?)	Dark shale.	Marcellus±	37	+0.5	H	5+	D	Flows a small amount. Reported tested at 40 gallons a minute with small draw-down. Temperature 53°F. Water contains excess iron; see analysis.
611	Tell Township																
611	1.8 miles northeast of Richvale (Shade Valley post office)	D. B. Foltz.....	Hillside	1,040	Dr	82	6	NB	(?)	Sandstone..	Oriskany.....	51	30±	H	5±	D	51 feet of loose sandstone cased.
612	0.9 mile north of Richvale	R. G. Goshorn....	Valley	900	Dr	60	6	NB	(?)	Limestone.	Cayuga.....	(?)	?	H	3-5	D	
613	Richvale.....	do.	do.	820	Dr	53	6	NB	(?)	do.	Helderberg....	(?)	?	H	3-5	D	
614	do.	Rudy Smith.....	do.	820	Dr	45	6	(?)	(?)	do.	do.	23	6	H	5+	D	
615	1.4 miles northwest of Nossville	Harvey Wiser....	Ridge	.....	Dr	90	6	(?)	(?)	Sandstone or shale	Chemung or Portage	20	?	H	3-5	D	Reported tested at 26 gallons a minute.
616	Nossville.....	J. L. Kling.....	Hillside	.....	Dr	68	6	NB	(?)	Dark ss. and shale	Hamilton.....	20	8±	H	3-5	D	
617	do.	J. W. Yocum.....	do.	.....	Dr	85	6	NB	(?)	do.	do.	28	30±	H	3-5	D	
618	0.4 mile southwest of Nossville	E. J. Love.....	Valley	.....	Dr	125	6	NB	(?)	Hard sandstone	do.	(?)	?	H	5±	D	
619	2.8 miles southwest of Nossville	Rudolph Chilcote..	Ridge	.....	Dr	88	6	NB	(?)	Dark shale.	Chemung or Portage	20	35±	H	3-5	D	
620	do.	David McMullough	Hillside	.....	Dr	50	6	NB	(?)	do.	do.	10	20±	H	3-5	D	
621	3.0 miles southwest of Nossville	L. Parsons.....	Valley	.....	Dr	80±	6	NB	(?)	Dark sh. or sandstone	Hamilton.....	20	15±	H	5±	D	

Typical wells and springs in Huntington County—Continued

No. on pl. 2	Location	Owner or name	Topographic situation	Altitude (feet) ^a	Type of supply ^b	Depth (feet)	Diameter (inches)	Principal water-bearing bed				Length of casing (feet)	Depth to water level (feet)	Method of lift ^c	Yield (gallons a minute)	Use of water ^f	Remarks
								Depth to top of bed (feet) ^d	Thickness (feet)	Character of material ^d	Geologic horizon						
622	Cromwell Township Rockhill.....	John Pile.....	Valley	.....	Dr	28.5	6	NB	(?)	Black shale.	Marcellus....	18	5	I	12	D	Water reported to contain hydrogen sulphide (H ₂ S) and to be unsuitable for drinking.
623	do.	East Broad Top R. R. & Coal Co.	Hillside	*750±	Dr	465	6	430	35	Sandy shale	Marcellus?....	33	35±	P	35	D	Reported temperature 52°F. Water reported soft. Supplies 10 houses and railroad shops.
624	Cass Township	Harper Stever.....	Valley	1,220	Dr	50	6	NB	(?)	Red shale....	Mauch Chunk	(?)	?	H	3-5	D	Limestone overlain by 20 feet of red shale. Reported low in dry weather.
625	1.7 miles west of Cassville	Oscar Stapleton...	Slope	1,170	Dr	50±	6	NB	(?)	Sandstone...	Burgoon.....	(?)	?	H	5±	D	
626	Tod Township	Charles Taylor.....	Valley	1,140	Dr	50	6	NB	(?)	Red shale....	Mauch Chunk	(?)	?	H	5±	D	Limestone overlain by 20 feet of red shale. Reported low in dry weather.
627	do.	C. H. Reed.....	do.	1,140	Dr	50	6	20	30	Limestone...	Trough Creek	20±	?	H	5±	D	
628	1.0 mile west of Tod	James McClain....	Slope	1,180	Dr	61.5	6	NB	(?)	Red shale....	Mauch Chunk	10	16±	H	5±	D	Reported low in dry weather.
629	1.0 mile east of Trough Creek	O. A. Horton.....	do.	1,210	Dr	38	6	NB	(?)	Sandstone...	Burgoon....	10	20±	H	3-5	D	
630	Trough Creek.....	H. H. Lamberson...	Hillside	1,170	Dr	50	6	NB	(?)	Red shale...	Mauch Chunk	(?)	?	H	3-5	D	Water reported hard.
631	Hopewell Township	Carl Treece.....	do.	970	Dr	28	6	NB	(?)	Shale.....	Wills Creek...	26	11	H	3-5	D	
632	Cherrytown.....	do.	do.	970	Dr	28	6	NB	(?)	Shale.....	Wills Creek...	26	11	H	3-5	D	Temperature 53°F. See analysis. See log of upper part. Small yield; never used.
632	Wood Township	Rockhill Coal & Iron Co.	Slope	1,780	Dr	293	4-6	NB	(?)	Green sandstone	Mauch Chunk	293	+2 or 3	F	1/4	D	
633	Robertsdale.....	do.	Valley	+1,863.9	Dr	452	10-8	NB	(?)	do.	do.	(?)	?	N	(?)	N	Temperature 53°F. See analysis. See log of upper part. Small yield; never used.
633	0.6 mile east of Woodvale (Wood post office)	do.	Valley	+1,863.9	Dr	452	10-8	NB	(?)	do.	do.	(?)	?	N	(?)	N	

^a Altitude from East Broad Top Railroad and Coal Co.

[†] Altitude from Rockhill Coal and Iron Co.

Clay Township	Mr. McClean...	Hillside	.....	Dr	60	6	NB	0.5	Channel in limestone Blue shale...	Heldberg±	30	35±	H	5±	D	Some mud in channel.
634 Three Springs....	Mr. McClean...	Hillside	.....	Dr	60	6	NB	0.5	Channel in limestone Blue shale...	Heldberg±	30	35±	H	5±	D	Some mud in channel.
635 3.5 miles south of Saltito	Noah Runk.....	do.	1,000	Dr	85	6	45	40	Blue shale...	Chemung?....	11	20±	H	1.5	D	
636 do.	George Fields....	do.	980	Dr	53	6	32	(?)	do.	do.	27	14±	I	12±	D	
Springfield Twp.																
637 Brownsville.....	Harris & Locke....	Valley	.....	Dr	40	6	NB	(?)	Green ss....	do.	8±	15±	H	5±	D	Supplies 2 houses.
Dublin Township																
638 0.4 mile north of Shade Gap	C. J. Hess...	Hillside	.....	Dr	60	6	NB	(?)	Dark sandstone	Clinton±....	30	10±	H	5±	D	Water reported to contain excess iron; not used for drinking.
639 0.3 mile east of Shade Gap	J. M. Harper.....	Ridge	.....	Dr	190	6	125±	0.5±	Sandstone...	Oriskany....	25	125±	P	5	D	Water between sandstone (100 feet thick) and lower clay (65 feet thick); lower 40 feet of clay caved in.
640 0.6 mile west of Neelyton	G. Gifford.....	Valley	.....	Dr	42	6	NB	(?)	Dark shale.	Hamilton or Mareellus	15±	20±	I	3-5	D	
641 Mentzer.....	G. Johnson.....	Ridge	.....	Dr	70	6	NB	(?)	do.	Hamilton?	15	35±	H	3-5	D	

• Altitude taken from nearest contour on topographic maps unless otherwise indicated. No

topographic map of southeastern corner of county.

• Dr; drilled well; Du, dug well; DD, dug and drilled well; Sp, spring.

• NB, near bottom.

• Sl, shale; ss, sandstone.

• B, bucket; F, natural flow; H, lift pump, hand-operated; I, pitcher pump, hand-operated; N, none;

P, force pump, power-operated; S, suction pump, power-operated; T, turbine pump.

• C, condensing or cooling; D, domestic; I, industrial; Ir, irrigation; N, none; S, stock.

Partial analyses of ground waters from Huntingdon County

[Analyzed by E. W. Lohr. Parts per million. Numbers at heads of columns refer to corresponding numbers in the preceding table and on pl. 2.]

	564	573	589	591
Iron (Fe).....				
Calcium (Ca)	^a 28	133	114	^a 8
Magnesium (Mg).....		32	11	
Sodium and potassium.....	17	44	37	5
(Na+K) ^c				
Bicarbonate (HCO ₃)	105	272	201	22
Sulphate (SO ₄).....	^a 17	223	20	^a 4
Chloride (Cl).....	1.0	74	150	1.0
Nitrate (NO ₃).....	.10	.0	17	3.7
Total dissolved solids ^c	113	640	448	32
Total hardness as CaCO ₃	68	^c 464	^c 330	16
Date of collection (1933).....	Oct. 10	Oct. 10	Oct. 10	Oct. 10

	593	610	632
Iron (Fe).....		6.1	
Calcium (Ca)	80	^a 45	^a 24
Magnesium (Mg).....	13		
Sodium and potassium (Na+K) ^c	^b	3	20
Bicarbonate (HCO ₃)	270	83	144
Sulphate (SO ₄).....	20	^a 60	10
Chloride (Cl).....	2.0	33	1
Nitrate (NO ₃).....	5.2	.10	.30
Total dissolved solids ^c	253	206	136
Total hardness as CaCO ₃	^c 253	171	86
Date of collection (1933).....	Oct. 13	Oct. 13	Oct. 13

^a By turbidity.^b Less than 5.^c Calculated.

Log of flowing well of Rockhill Coal & Iron Co., at Robertsdale

[No. 632. Authority, chief engineer.]

	Thickness (feet)	Depth (feet)
Surface soil.....	22	22
Slate, black.....	8	30
Sandstone, gray (Homewood).....	51	81
Coal and slate (Mount Savage or Mercer?).....	2	83
Slate, black, sandy.....	15	98
Sandstone, gray.....	17	115
Slate, black, sandy } Connoquenessing.....	5	120
Sandstone, gray.....	86	218
Sandstone, green.....	7	225
Shale, green.....	5	230
No record, alternating green sandstone and red shale (Mauch Chunk)....	63	293

JUNIATA COUNTY

Area 392 square miles. Population (1930) 14,325.

GEOGRAPHY

Juniata County is a mountainous, sparsely populated county with only about 37 inhabitants to the square mile, as against 215 for the entire State. The largest borough in the county is Mifflintown, which had a population of 1,027 in 1930. About 56 percent of the total land area is devoted to agriculture, the principal industry. The Federal census of 1929 credits the county with only 20 industrial establishments whose products were valued at \$5,000 or more annually, one less than in any other county covered by this report. The main line of the Pennsylvania Railroad and the William Penn Highway follow the Juniata River along the only practicable east-west route in the 50-mile length of the county.

The topography of Juniata County is typical of the Ridge and Valley province, and the east and west boundaries of the southwestern two-thirds of the county are the summits of high, even-crested ridges. In the part that has been mapped topographically, which includes all but the southeast end, the highest point is on Blacklog Mountain, which stands 2,260 feet above sea level in Beale Township. Tuscarora Mountain has an altitude of 2,120 feet at one point in Turbett Township, and Shade Mountain is 2,000 feet high in some places. The Juniata River leaves the county at an altitude of about 380 feet, the lowest point in the county. The maximum relief is therefore about 1,880 feet. The mountains noted above stand 1,400 to 1,600 feet above the bottoms of the adjacent valleys. Except for a small area at the east end, which is drained by the West Branch of Mahantango Creek and other tributaries of the Susquehanna River, Juniata County is drained entirely by the Juniata River, which flows across the center of the county.

GEOLOGY

The rock formations in Juniata County range from undifferentiated Ordovician limestones (oldest), exposed only in Blacklog Valley, at the westernmost corner of the county, to the Portage group, of Upper Devonian age (youngest), exposed only in the southwestern part of the county (pl. 1). In addition there are thin deposits of Pleistocene age along the Juniata River. The character and water-bearing properties of these formations are described in the first part of this report. The larger part of the county is underlain by Silurian and Devonian strata, most of which have not been differentiated and mapped with much detail.

For example, the Clinton formation and the Cayuga group—the latter consisting of four separate formations—were all mapped together, and the same is true of the Middle and Upper Devonian formations. For this reason only the approximate geologic horizon is given for many of the wells in the accompanying well tables. The major folds trend northeast, curving toward the east, but the geology has not been mapped with sufficient detail to reveal the presence or extent of faults.

GROUND WATER

The limestones and calcareous shales of the Cayuga group and to some extent the Helderberg limestone are the water-bearers most extensively utilized in Juniata County, owing principally to the fact that these rocks underlie almost all the fertile valley areas in the county. About 65 percent of the wells for which records are tabulated below tap the Cayuga group, the rocks of which are also probably the most productive water-bearers in the county. The Oriskany group generally forms a ridge separating the fertile valleys of Silurian rocks from the rolling, hilly areas of Devonian rocks. Nearly all the wells in the county are used for domestic purposes or stock, and dug wells appear to be more numerous than drilled wells in most of the farms and villages. Small mountain or hillside springs are used in many places and furnish a few public supplies, but no large springs were observed.

In a few of the towns along the Juniata River drilled wells are used to supply cooling water to dairies, and there are several other wells at plants no longer in operation. (See wells 722, 729, 753, and 768.) Well 722, at Mifflintown, yields 275 gallons a minute from a limestone in the Cayuga group, the largest yield reported in the county.

Only three flowing wells were reported in Juniata County (wells 757, 774, and 776), but the water level in some of the other wells stands close to the ground surface. Additional wells of this type might be obtained locally, particularly in the areas underlain by Devonian rocks, but there appear to be no areas where large flows might be expected.

Analyses of 5 samples of ground water from wells and springs in Juniata County are tabulated below. The sample from a spring in the Clinton formation was very soft, as shown by analysis 719. The three waters from the Cayuga group were very hard as shown by analyses 721, 722, and 733, and one contained 0.37 part per million of iron. Many waters from the Cayuga in Bedford

and Mifflin Counties are much harder than these, owing to large amounts of calcium sulphate. Analysis 740, from the Hamilton or Portage, indicates a good, slightly hard water.

As most of the wells in the county penetrate the Cayuga group, it is safe to say that most of the ground waters are probably rather hard. The quality of water to be expected from the Cayuga and the other formations is summarized on pages 80, 81.

PUBLIC SUPPLIES

Only six public water supplies were noted in Juniata County. Mifflintown and Macedonia are supplied exclusively with surface water, McAllisterville and Richfield are supplied entirely from springs, and Port Royal and Thompsontown are supplied from springs and streams.

McAllisterville is supplied by the McAllisterville Water Co. from two small springs that issue from the Clinton formation in McAllister Gap, 2.3 miles northwest of the village. The springs yield 15 and 18 gallons a minute, and ordinarily only the larger one is used. The water flows by gravity to a 33,000-gallon concrete reservoir on Slim Valley Ridge, whence it is distributed by gravity at an average pressure of about 75 pounds to the square inch. There are six fire hydrants in the system. The average daily consumption is 5,000 gallons, all of which represents domestic use. The water is not treated and is very soft, as shown by analysis 719.

Port Royal (population 579) is supplied by the Port Royal Water Supply Co. from four small springs that issue from the Clinton formation on the north slope of Tuscarora Mountain $2\frac{1}{2}$ miles south of the borough. In exceptionally dry weather one small stream furnishes an auxiliary supply. There are three reservoirs having an aggregate capacity of 1,000,000 gallons—two near the springs and one on a hill just north of the borough. The water is distributed by gravity at an average pressure of about 75 pounds to the square inch. There are 22 fire hydrants in the system, and water is supplied to about 240 families, a dairy, and a silk mill. The water is chlorinated.

Richfield is supplied from three small springs owned by J. C. Boyer, and two more springs are held in reserve. The springs issue from the Clinton formation on the side of Shade Mountain in Snyder County, about $1\frac{1}{2}$ miles northwest of Richfield. The three springs ordinarily used are reported to yield an aggregate of 17,000 to 100,000 gallons a day. The springs discharge into a 5,000-gallon concrete reservoir, whence the water is distributed

by gravity at an average pressure of 75 pounds to the square inch. There is one fire hydrant. The daily consumption averages 15,000 gallons, all for household use. The water is occasionally chlorinated in the summer, but ordinarily this is not necessary.

Thompsons town (population 325) is supplied by the Thompsons town Waterworks from a small stream about 1½ miles northeast of the borough and a limestone spring in the borough. The stream flows into a concrete reservoir holding about 40,000 or 50,000 gallons, from which the water is distributed by gravity. The spring, which issues from the Cayuga group, is reported to yield more than 60 gallons a minute and is used only during dry summers, or occasionally for as long as 8 months of the year. Water from the spring is pumped directly into the distributing mains at a rate of 60 gallons a minute. The pressures range from 20 to 80 pounds to the square inch, and there are 14 fire hydrants. About 450 people are supplied. The water is chlorinated. It is reported that there are several other limestone springs in the borough, with larger yields than the one used. At one time well 769, near the reservoir, was used as an auxiliary supply, but the well was abandoned in favor of the spring.

Typical wells and springs in Juniata County

No. on pl. 2	Location	Owner or name	Topographic situation	Altitude (feet) ^a	Type of supply ^b	Depth (feet)	Diameter (inches)	Principal water-bearing bed		Length of casing (feet)	Depth to water level (feet)	Method of lift ^d	Yield (gallons a minute)	Use of water ^e	Remarks
								Character of material ^c	Geological horizon						
711	Monroe Township Eversdale.....	A. C. Goodling.....	Valley	720	Dr	30±	6	Calcareous sh.	Cayuga.....	(?)	?	H	3±	D	
712	Fayette Township Cooclamus.....	J. D. Lefher.....	do.	640	Dr	44	6	Limestone	Onondaga?...	20	24±	H, P	3±	D	
713	Bunkertown.....	Mrs. Scholl.....	do.	700	Dr	94	6	Calcareous sh.	Cayuga.....	(?)	?	H	3±	D	
714	0.7 mile northeast of McAllisterville	James Long.....	do.	680	Dr	58	6	Limestone	do.	20	10±	H	3±	D	
715	McAllisterville.....	C. E. Kaufman.....	do.	660	Dr	75	6	do.	do.	20	35±	H	3	D	
716	do.	Dr. I. G. Headings...	do.	660	Dr	46	6	Soft, shaly limestone	do.	16	14±	H	3±	D	
717	do.	Wilson Benner.....	do.	650	Dr	52	6	Limestone	do.	16	18±	H	3±	D	
718	0.5 mile west of McAllisterville	Frank Writter.....	Slope	650	Dr	92	6	do.	do.	16	36±	H	3±	D, S	
719	2.3 miles northwest of McAllisterville	McAllisterville Water Co.	Hillside	1,050±	Sp			Shale and sandstone	Clinton.....			F	18	P	Temperature 54°F. See analysis. An auxiliary spring nearby yields about 15 gallons a minute.
720	Oakland Mills.....	Mrs. Shirk.....	Slope	570	Dr	50	6	Limestone	Cayuga.....	10	30±	H	1-2	D	
721	Fermanagh Township 1.1 miles southwest of Oakland Mills	James B. Wilson.....	do.	580	Dr	68	6	Red shale.....	do.	10	18±	H	3±	D	Temperature 54°F. See analysis.
722	Mifflintown.....	Mifflin Creamery.....	Valley	420	Dr	140	8	Limestone	do.	40	15±	T	275	C	Reported moderate draw-down at 275 gallons a minute. Tempera- ture 53°F. See analysis.
723	0.5 mile northeast of Cuba Mills	Floyd Britcher.....	Hillside	530	Dr	154	6	Red and gray shale	do.	20	44±	H	3-5	N	Water obtained at depth of 144 feet. Owner uses spring.
724	1.8 miles east of Macedonia	G. W. Whistler.....	Valley	470	Dr	50	6	(?)	do.	(?)	?	H	3±	D	
725	Milford Township Denholm.....	William Paden.....	do.	480	Dr	70	6	Limestone	do.	21	36±	H	3±	D	Water obtained at depth of 60 feet.
726	1 mile southwest of Mifflin	Guy Stuart.....	do.	470	Dr	96	6	Red and gray shale	do.	28	38±	H	3±	D	

727	0.6 mile northwest of Port Royal	William Icenburg.....	do.	440	Dr	94	6	do.	Cavuga or Clinton	15	26±	H	3±	D	Reported draw-down 134 feet at 15 gallons a minute. Abandoned because of small yield. Reported draw-down 78 feet on pumping 85 gallons a minute for 2 days. See log.
728	Port Royal.....	Breyer Ice Cream Co.	do.	440	Dr	210	8	Red and black shale	Cavuga.....	18	33	N	15—	N	
729	do.	do.	do.	440	Dr	263	8	Blue shale.....	do.	57	29	T	85	1	
730	2.6 miles southwest of Port Royal	Margaret and Mary Groninger	Knoll	520	Dr	95	6	Limestone.....	do.	30	55±	H	5±	D	
731	2.7 miles southwest of Port Royal	Ralph Gilsen.....	do.	520	Dr	78	6	do.	do.	20	42±	H	7±	D	
732	1.2 miles northeast of Walnut	George C. Wilson....	Slope	550	Dr	125	8	do.	Tonoloway?	12	1±	S	5+	D	
733	do.	do.	do.	550	Dr	125	6	do.	do.	21	20±	P	18	D	Yield measured Aug. 23, 1934. Temperature 53°F. See analysis. Water used for swimming pool.
Beale Township															
734	0.3 mile southwest of Acadenia	W. S. Burd.....	Valley	540	Dr	20	6	Calcareous shale?	Cavuga.....	(?)	10±	H	3±	S	
735	1.1 miles southwest of Academia	David Haekenberry...	do.	520	Dr	61	6	Limestone.....	do.	8±	15±	H	3±	D	
Tuscarora Township															
736	McCoville.....	S. C. Henry.....	Hill	...	Dr	80±	6	Shale.....	Helterberg?	40±	38±	H, P	3±	D	
737	1.7 miles northeast of Reeds Gap	Stewart Slitt.....	Slope	...	Dr	62	6	Dark sandy shale	Cavuga.....	16	10±	L	3±	D	
738	Reeds Gap.....	Samuel Woodward...	do.	...	Dr	55±	6	Limestone?	do.	(?)	?	H	3±	D	
739	East Waterford.....	Robert Love.....	Valley	...	Dr	35	6	Gravel.....	Recent	25	15±	H	?	D	
Lack Township															
740	2.3 miles southwest of McCullocks Mills	State Game Turkey Farm	Hillside	...	Dr	172	6	Black shale.....	Hamilton or Portage	15	20±	P	4 5	D	Reported draw-down 50 feet on bailing 16 gallons a minute for 1 hour. See analysis. Water reported to contain hydrogen sulphide. Water reported hard.
741	Peru Mills.....	Ada B. Henry.....	Valley	...	Dr	85±	6	Shale....	Marcellus.....	(?)	20±	H	3±	D	
742	0.5 mile northeast of Cross Keys	I. C. Vaughn.....	do.	...	Dr	55	6	Black shale.	do.	20	3±	H	3±	D	
743	Cross Keys.....	Samuel Burdge.....	do.	...	Dr	76	6	Dark sandy shale	do.	18	5±	H	3±	D	
744	Waterloo.....	Charles Devin.....	Slope	...	Dr	70±	6	Black shale?	Cavuga.....	12	20±	H	6	D	Driller's location not checked. Do.
745	1.5 miles southwest of Perlack	Watson Newman....	do.	...	Dr	60	6	Limestone.....	do.	57	40±	H	5	D, S	
746	0.3 mile northeast of Perlack	Lowry McClure.....	do.	...	Dr	65	6	Gray shale.....	do.	22	21±	H	3±	D	

Typical wells and springs in Juniata County—Continued

No. on plat. 2	Location	Owner or name	Topographic situation	Altitude (feet) ^a	Type of supply ^b	Depth (feet)	Diameter (inches)	Principal water-bearing bed		Length of casing (feet)	Depth to water level (feet)	Method of lift ^d	Yield (gallons a minute)	Use of water ^e	Remarks
								Character of material ^c	Geologic horizon						
	Spruce Hill Township														
747	1.6 miles southwest of Pleasant View	Charles Simonton.....	Slope	.....	Dr	52	6	Yellow shale.	Cayuga.....	21	16±	H	3±	D	
748	0.3 mile south of Pleasant View	Thomas Hackenberry	Valley	580	Dr	52	6	Red and gray shale	do.	12	10±	H	3±	D	
749	Spruce Hill.....	Stanley Swartz.....	do.	500	Dr	30	6	Shale.....	do.	25	5±	H	3±	D	
	Turbett Township														
750	1.9 miles southwest of Port Royal	H. S. Swartz.....	Slope	450	Du	40	48±	Thin-bedded limestone and shale	do.	40	34 to 39	H?	(?)	D	U. S. Geological Survey observation well, discontinued November, 1932; see pp. 35-39.
751	Old Port.....	George Hertzler.....	Hillside	470	Dr	66	6	Black shale...	Marcellus....	20	31	H	3±	D	Drillers encountered hard lumps of pyrite in shale.
752	0.6 mile northwest of Tuscarora	G. W. Leister.....	Slope	450	Dr	75	6	Limestone....	Cayuga.....	14	35±	H	3±	D	
753	0.4 mile southeast of Mexico	Supplee-Willis-Jones Milk Co. (former owner)	Valley	430	Dr	85	8	do.	do.	43	39±	N	80±	N	Plant torn down; well abandoned and filled.
	Walker Township														
754	0.7 mile northeast of Port Royal	Samuel Bashore.....	Knoll	560	Dr	121	6	Red and gray shale	do.	21	69±	H	1-2	D	
755	0.7 mile northwest of Mexico	Mr. Henderson.....	Slope	510	Dr	100	6	Red shale....	do.	42	52±	P	5±	D, S	Soft limestone overlies red shale.
756	Mexico.....	Earl Haek.....	Valley	430	Dr	47	6	Black shale...	Marcellus....	19	3±	S	4+	D	Water reported to be hard and to contain hydrogen sulphide.
757	1.9 miles northeast of Mexico	Paul Frymire.....	do.	460	Dr	50	6	Red shale.....	Cayuga.....	28	+? to 2.5	I	3±	D	Reported to flow in winter. Depth to water level 2.5 feet August 20, 1934.
758	2.1 miles southwest of Van Wert	Elmer Kaufman heirs	Slope	500	Dr	137	6	Red and gray shale	do.	(?)	79±	H	3±	D	
759	Van Wert.....	Ross Bashore.....	Valley	580	Dr	40	6	Calcareous sh.	do.	(?)	?	H	3±	D	

Analyses of ground waters from Juniata County

[Analyzed by E. W. Lohr. Parts per million. Numbers at heads of columns refer to corresponding numbers in preceding table and on pl. 2.]

	719	721	722	733	740
Silica (SiO ₂).....			12		
Iron (Fe).....		0.37	.04	0.05	
Calcium (Ca).....	a 2	86	82	94	a 30
Magnesium (Mg).....		24	25	40	
Sodium (Na).....	b 1	b 5	35	b 10	b 19
Potassium (K).....			2.2		
Bicarbonate (HCO ₃).....	9.0	308	286	433	132
Sulphate (SO ₄).....	a 4	a 20	51	50	a 16
Chloride (Cl).....	.6	17	61	3.0	1.1
Nitrate (NO ₃).....	.10	34	11	11	.10
Total dissolved solids.....	b 14	b 338	429	b 421	b 134
Total hardness as CaCO ₃	10	b 313	b 308	b 399	86
Date of collection (1934)....	Aug. 18	Aug. 20	Aug. 20	Aug. 23	Aug. 23

^a By turbidity.

^b Calculated.

Log of Breyer Ice Cream Co's. well at Port Royal

[No. 729. Authority, H. K. Hornberger, driller]

	Thickness (feet)	Depth (feet)
Clay, yellow.....	15	15
Shale, red (very little water).....	60	75
Slate, black (some water at 120 feet).....	45	120
Shale, red.....	25	145
Limestone.....	17	162
Shale, red.....	18	180
Shale, blue, calcareous.....	17	197
Shale, very red (tested at 50 gallons a minute at a depth of 200 feet).....	12	209
Slate, blue (water-bearing).....	54	263

MIFFLIN COUNTY

Area 398 square miles. Population (1930) 40,335

GEOGRAPHY

With about 101 inhabitants to the square mile, as against 215 for the State, Mifflin County ranks third in density of population among the counties covered by this report. Lewistown, which had 13,357 inhabitants in 1930, is the largest borough in the county and the fourth largest in the area. The only other borough in the county with 1,000 or more inhabitants is Burnham, which had 3,089 in 1930. The Federal census of 1929 credits the county with 49 industrial establishments whose products were valued at \$5,000 or more annually. The largest individual industry is the manufacture of rayon at Viscose, across the river from Lewistown, and most of the other manufacturing is in Lewistown and Burnham. Glass sand, ganister, and limestone are quarried. About 48 percent of the total land area of the county is under cultivation. The most prosperous farms are in the large and fertile Kishacoquillas Valley. The main line of the Pennsylvania Railroad and the William Penn Highway follow the Juniata River across the southern part of the county.

The topography in Mifflin County is typical of the Ridge and Valley province. Like those of Juniata County, the east and west boundaries of Mifflin County are the summits of long, narrow, even-crested ridges. Jacks Mountain, near Mount Union, stands at an altitude of 2,340 feet—the highest known point in the county so far as topographic maps are available. Other high points are Standing Stone Mountain, 2,320 feet; Shade Mountain, 2,260 feet; and Blue Mountain, 2,100 feet. The Juniata River leaves the county at an altitude of about 430 feet—the lowest point in the county. The maximum relief therefore is about 1,910 feet. Mifflin County is drained entirely by the Juniata River except for a few square miles in the northernmost part, which is drained by Penns Creek, a tributary of the Susquehanna River.

GEOLOGY

The rock formations exposed in Mifflin County range from the undifferentiated Ordovician limestones and dolomites and possibly some beds of Cambrian age exposed in the Kishacoquillas Valley to the Marcellus shale and possibly part of the overlying Hamilton formation, both of Middle Devonian age, exposed in a narrow band extending through the county northeastward from Newton Hamilton (pl. 1). There are also shallow deposits of Pleistocene and Recent material along the Juniata River. The

character and water-bearing properties of these formations are described in the first part of this report. The high ridges are capped by the Tuscarora quartzite. The larger part of the Juniata Valley is underlain by the Cayuga group, the several bands of which are separated by ridges of the Oriskany group and the Helderberg limestone and hilly or rolling areas of the Middle Devonian rocks. As in Juniata County, most of the formations have not been differentiated and mapped in any detail, so that in the time available only approximate geologic correlations could be made for many of the wells and springs. The principal folds trend northeast and curve gently toward the east. Standing Stone Mountain is offset by a fault in Union Township.

GROUND WATER

The most productive water-bearing formations that have been exploited in Mifflin County are the Ordovician limestones and dolomites in Kishacoquillas Valley and the limestones of the Cayuga group and Helderberg limestone in the large valley area east of Jacks Mountain.

The Ordovician limestones and dolomites give rise to several large springs, such as nos. 654, 658, and 665, and to numerous smaller springs. Except for wells 663 and 664, in Bellville, which furnish water for cooling, most of the wells in these limestones are used only for domestic and stock supply, so that the maximum water-yielding capacity has not been determined. Likewise, the younger limestones of the Cayuga and Helderberg furnish mainly domestic and stock supplies except in the vicinity of Lewistown, where records were obtained of six wells that are pumped at rates of 35 to 360 gallons a minute, four of them yielding more than 100 gallons a minute each. (See wells 689 to 695.)

The Reedsville shale and the Middle Devonian shales yield small but generally reliable supplies. The Oriskany group forms steep ridges and is therefore tapped by only a few wells, but it supplies some small springs and furnishes McVeytown with water. (See below.) The Clinton, Tuscarora, Juniata, and Oswego are relatively unimportant as sources of water owing to their topographic position, but the Clinton supplies a few hillside wells.

Dug wells and springs furnish a large part of the water in the villages and farms, but drilled wells are also used in many places. Small mountain springs are piped to some of the farms in the adjacent valleys, particularly along the borders of Kishacoquillas Valley. Cisterns are also used by some of the residents of this valley.

Records were obtained of only three flowing wells in Mifflin County (wells 664, 670, and 694), only one of which flows perennially. There appear to be no particular areas where such wells could be obtained in any considerable number.

Analyses of 5 samples of water from as many geologic formations in Mifflin County are given below, and the quality of water to be expected from the different formations in the county is summarized on pages 80, 81. The sample from the Oriskany was soft, as shown by analysis 671, but all the others were moderately hard to very hard. Analysis 694, of a sample from the Cayuga group, indicates a highly mineralized, extremely hard water, containing principally calcium sulphate. Most of the Cayuga waters are very hard, though probably few others are as hard as 694. Four of the five samples contained 0.4 to 0.87 part per million of iron, but this does not indicate that iron-bearing waters are widespread in the county, as few of the well owners reported any trouble due to excessive iron content.

PUBLIC SUPPLIES

A few of the larger boroughs in Mifflin County have surface-water supplies, and McVeytown has the only ground-water supply. Those supplied with surface water include Allenville, Burnham, Highland Park, Lewistown, Menno, Reedsville, Yeager-town, and the Viscose plant at Viscose.

A part of McVeytown (population 566) is supplied by the McVeytown Private Water Co. from an abandoned sand mine tunnel used as an infiltration gallery. The tunnel penetrates a hill composed of the Oriskany group and was once used for mining glass sand. Water from the tunnel is pumped to a 34,000-gallon reservoir by a gasoline-driven pump at a rate of about 38 gallons a minute, the pump being operated about 6 hours a week. The water is distributed by gravity and supplies 10 or 11 families. The average daily consumption is less than 2,000 gallons. The water is not treated and is of good quality, as shown by analysis 671.

Typical wells and springs in Mifflin County

No. on pl. 2	Location	Owner or name	Topographic situation	Altitude (feet) ^a	Type of supply ^b	Depth (feet)	Diameter (inches)	Principal water-bearing bed		Length of casing (feet)	Depth to water level (feet)	Method of lift ^d	Yield (gallons a minute)	Use of water ^e	Remarks
								Character of material ^c	Geologic horizon						
Armagh Township															
642	3.5 miles north of Siglerville	W. O. Rerick and others	Upland	2,040	Dr	78	6	Sandstone....	Clinton.....	18	22±	H	5	D	Driller's location not checked. Sand- stone below 64 feet of red shale. Reported draw-down 3 or 4 feet at 20 gallons a minute.
643	0.6 mile northeast of Siglerville	Stewart Brown.....	Valley	780	Dr	53	6	Black shale...	Reedsville...	12	20±	H,P	5+	D,S	
644	0.3 mile northeast of Siglerville	Margaret Mayes....	do.	760	Dr	42±	6	do.	do.	(?)	17±	H	3±	D,S	
645	Siglerville.....	Emory Krebs.....	do.	740	Dr	40	6	do.	do.	20	22±	H	3±	D	
646	do	Charles Peight.....	do	730	Dr	52	6	Shaly lime- stone	Middle Ordovician	20	17±	H	3±	D	
647	do	Ralph Peight.....	do	730	Dr	52	6	Black shale....	Reedsville.....	24±	12±	H	3±	D	Water in small crevice at 92 feet. Reported small draw-down at 20 gallons a minute. Drilled 202- foot dry hole near this well. Temperature 56°F. See analysis.
648	0.3 mile west of Siglerville	Burns Alexander....	Knoll	800	Dr	124	6	Limestone....	Middle Ordovician	4	64±	H	5+	D,S	
649	1.1 miles south of Siglerville	Robert Hassinger....	Slope	720	Dr	35	6	Black shale....	Reedsville....	16	17±	H	3±	D	Reported small draw-down at 20 gallons a minute for 5 minutes.
650	do.	Thomas Swartzel....	do.	720	Dr	49	6	do.	do.	25	9±	H	5+	D	
651	Loeke Mills.....	B. Keeney.....	Valley	700	Dr	80	6	do.	do.	25	?	H	3-5	D	Discharges from Wet Cavern of Alexander Caverns. Large yield estimated at several thousand gallons a minute. Water muddy after rain.
652	0.7 mile northwest of Milroy	Mr. Knepp.....	Slope	860	Dr	42	6	do.	do.	12	7±	H	3-5	D	
653	do.	Mrs. Artman.....	do.	860	Dr	52	6	do.	do.	10	7±	H	3-5	D	Reported draw-down 15 feet at 20 gallons a minute. Reported small draw-down at 20 gallons a minute.
654	0.4 mile north of Honey Creek	R. M. Alexander and Sisters, Mammoth Spring	Valley	680	Sp	.....	.....	Channel in limestone	Middle Ordovician	.....	.....	F	(?)	N	
Brown Township															
655	1.1 miles northeast of Reedsville	Reed estate.....	Ridge	760	Dr	225	6	Limestone....	do.	(?)	120±	P	10	D	
656	0.4 mile north of Reedsville	do.	do.	720	Dr	225	6	do.	do.	(?)	80±	P	10	D	
657	0.9 mile west of Reedsville	T. V. McMann.....	Upland	730±	Dr	140	6	do.	do.	(?)	100±	P	5±	D	

658	0.9 mile west of Cedar Hills	Ennis Yoder	Valley	720	Sp	.....	.....	Channeled limestone	Lower or Middle Ordovician	.....	.....	F	500±	D	Temperature 51°F. Yield estimated
659	Barrville	Harry Switzer	Hillside	950	Dr	74	6	do.	Middle Ordovician	(?)	.....	N	O	N	Some water encountered at 51 feet but was drained by a dry channel below.
660	Union Township														
660	Alexander Springs	J. A. Haughwout, Alexander Springs	Valley	740	Sp	.....	.....	do.	Lower or Middle Ordovician	.....	.....	F	30±	N	Temperature 52°F. Yield estimated.
661	1.7 miles northeast of Belleville	Harrison Kaufman	Slope	840	Dr	101	6	Limestone	do.	4	61±	A	5±	D,S	
662	1.6 miles northeast of Belleville	J. Y. Hostetler	do.	880	Dr	189	6	do.	do.	8±	120±	P	6	D,S	
663	Belleville	Penn Reed Milk Co.	Valley	800	Dr	42	8	do.	do.	(?)	1±	P	60±	C	Drilled 62 feet, but filled up 20 feet with fine sand.
664	do.	Ka-Vee Ice Cream Co.	do.	800	Dr	60	6	do.	do.	(?)	+ to 8	S	6.5	C	Temperature 53°F. See analysis.
665	Menno Township														
665	1 mile south of Menno	Botto Swarey	do.	860	Sp	.....	.....	Channels in limestone	do.	.....	.....	F	500-1,000±	D,S	Temperature 51°F. Yield estimated. Cloudy after rain.
666	Wayne Township														
666	Newton Hamilton	Mr. Carwell	do.	540	Dr	46	6	Hard ss.	Oriskany (?)	10	20±	H	1-3	D	
667	1.1 miles east of Newton Hamilton	Bentler, Hunter & Ewing	do.	520	Dr	62	6	Sandstone	Oriskany	50	10±	H	3±	D	
668	Atkinson Mills	C. R. Witzel	Slope	770	Du	90	30±	do.	do.	90	80±	H	3±	D	
669	Bratton Township														
669	Mattawana	R. M. Miller	do.	.....	Dr	60	6	Red shale	Cayuga	40	30±	H	3±	D	Water enters at depth of 105 feet. Limestone overlain by red shale.
670	do.	D. McKean	do.	.....	Dr	107	6 1/4	Crevice in limestone	do.	30	+3 to 1	S	5±	D	Reported to flow a small amount in winter. Water level 1 foot below surface August 17, 1934.
671	Oliver Township														
671	0.3± mile west of McVeytown	McVeytown Private Water Co.	Canyon	.....	IG	.....	.....	Sandstone	Oriskany	.....	.....	F	30±	P	Sand mine drift used as infiltration gallery. Temperature 55°F. See analysis and p. 253.
672	McVeytown	Charles Andrews	Slope	.....	Dr	51	6	Channeled limestone	Cayuga	30	21±	P	5±	D	Reported small draw-down at 20 gallons a minute.
673	do.	Firman Clark	do.	.....	Dr	85±	6	Limestone	do.	40	?	P	5±	D	
674	2.2 miles northeast of McVeytown	E. E. Ripkey	Hillside	590	DD	80	6	Limestone	do.	50	40±	H	3±	D	
675	2.6 miles northeast of McVeytown	Dan Miller	Valley	510	Dr	44	6	Yellow shale Hard sandstone	Clinton?	20	19±	H	3±	D	

Typical wells and springs in Mifflin County—Continued

No. on pl. 2	Location	Owner or name	Topographic situation	Altitude (feet) ^a	Type of supply ^b	Depth (feet)	Diameter (inches)	Principal water-bearing bed		Length of casing (feet)	Depth to water level (feet)	Method of lift ^c	Yield (gallons a minute)	Use of water ^e	Remarks
								Character of material ^e	Geologic horizon						
676	Granville Township	J. M. Cargill.....	Slope	540	Dr	54	6	Limestone....	Cayuga.....	12	24±	H	3±	D	Reported draw-down 70 feet at 14 gallons a minute.
677	Strodes Mills.....	R. Y. & J. M. Cargill	do.	620	Dr	123	6	Thin-bedded shaly ls.	do.	14	50±	P	1	D	
678	Strodes Mills do.	do.	do.	620	Dr	335	6	Calcareous sh.	do.	15±	90±	P	9.5	D	
679	1.9 miles northeast of Strodes Mills	Mr. Dugli.....	Hillside	780	Dr	255	6	Limestone....	Helderberg or Tonoloway	40	200±	P	5±	D	46 feet of loose sand cased.
680	2.5 miles northeast of Strodes Mills	Dr. Chambers.....	do.	680	Dr	109	6	Limestone....	do.	40	50±	P	5±	D	
681	2.4 miles southwest of Lewistown	George Lewis.....	do.	660	Dr	56	6	Sandstone....	Oriskany?....	46	41±	H	3-5	D	
682	do.	Loc-Len Inn.....	do.	640	Dr	74	6	Limestone....	Helderberg....	40	?	P	3-5	D	30 feet of sand cased.
683	1 mile southwest of Granville	A. S. Farrell.....	Valley	470	Dr	53	6	do.	Cayuga.....	30	28±	H	3±	D	
684	Granville.....	Harry Reitz.....	do.	500	Dr	92	6	do.	do.	50	30±	H	5±	D	
685	do.	Granville School.....	do.	520	Dr	66	6 1/4	Red shale....	do.	30	20±	H	3-5	D	50 feet of sand cased. Reported small draw-down at 28 gallons a minute.
686	1.2 miles east of Granville	Thomas Singleton....	do.	500	Dr	52±	6	Dark shale....	do.	37	17±	H	3±	D	
687	1.4 miles east of Granville	Louis Lakey.....	do.	500	Dr	51	6	Limestone....	do.	30	31±	H	3±	D	
688	0.7 mile southeast of Viscose	Mrs. William Good- man	Hillside	560	Dr	80	6	Red shale....	Clinton.....	40	40±	H	3±	D	Reported draw-down 23 feet at 360 gallons a minute. About 56 feet of clay with some boulders over- lies limestone. Some water ob- tained at depths of 48 and 58 feet; main supply at 62 feet. Reported large draw-down at 25 gallons a minute. Main supply at depth of 100 feet.
689	Viscose.....	Viscose Co.....	Valley	480	Dr	161	8	Limestone....	Cayuga.....	(?)	35±	T	360	C	
690	do.	do.	do.	460	Dr	203	8	do.	do.	31.6	100±	N	25-	N	

Analyses of ground waters from Mifflin County

[Analyzed by E. W. Lohr. Parts per million. Numbers at heads of columns refer to corresponding numbers in the preceding table and on pl. 2.]

	649	664	671	694	708
Silica (SiO ₂).....		8.2			
Iron (Fe).....	0.43	.02	0.86	0.87	0.72
Calcium (Ca).....	^a 26	60	^a 18	480	60
Magnesium (Mg).....		30		121	8.5
Sodium (Na).....	} ^b 14	{ 11 1.9	} ^b 5	^b 5	^b 11
Potassium (K).....					
Bicarbonate (HCO ₃).....	164	254	50	202	151
Sulphate (SO ₄).....	^a 10	27	^a 7	1,464	68
Chloride (Cl).....	1.0	28	1.0	5.0	10
Nitrate (NO ₃).....	.10	22	.70	.0	.20
Total dissolved solids.....	^b 152	312	^b 54	^b 2,174	^b 232
Total hardness as CaCO ₃	116	^b 273	40	^b 1,696	^b 185
Date of collection (1934)....	Aug. 14	Aug. 14	Aug. 15	Aug. 14	Aug. 14

^a By turbidity.

^b Calculated.

PERRY COUNTY

Area 564 square miles. Population (1930) 21,744

GEOGRAPHY

Perry County is a mountainous, sparsely populated county with only about 39 inhabitants to the square mile, as against 215 for the entire State. Marysville, Duncannon, and Newport are the only boroughs having 1,000 or more inhabitants, and the largest is Marysville, which had 1,922 in 1930. About 58 percent of the total land area is devoted to agriculture, which is the principal industry. The Federal census of 1929 credits the county with 37 manufacturing establishments whose products were valued at \$5,000 or more annually. The larger settlements and most of the industries are situated along the Susquehanna River, which forms the eastern boundary, or along the Juniata River, which traverses the eastern part of the county. The main line of the Pennsylvania Railroad parallels these two rivers through the county, and the William Penn Highway and the Susquehanna Trail parallel the Juniata and Susquehanna, respectively.

The topography in Perry County is typical of the Ridge and Valley province and is especially mountainous in the southwestern part. (See pl. 4, B.) The highest known parts of the county are

in Toboyne Township, where Rising Mountain and two points on Blue Mountain have altitudes of 2,240 feet. Parts of Toboyne and Jackson Townships have not been mapped topographically and may contain higher points. The Susquehanna River leaves the county north of Harrisburg at an altitude of about 310 feet—the lowest point in the county. The maximum relief is therefore about 1,930 feet. Many of the ridges rise 1,200 to 1,400 feet above the bottoms of the adjacent valleys. Perry County is drained entirely by the Juniata and Susquehanna Rivers.

GEOLOGY

The Paleozoic rocks exposed in Perry County range from the undifferentiated Ordovician limestones exposed in Horse Valley (oldest) to the Mauch Chunk shale, of Mississippian age, exposed along the Susquehanna River in The Cove and in Hunters Valley (youngest). Several dikes of Triassic diabase cut older strata in the southeastern part of the county, and deposits of Pleistocene and Recent age are found at some places along the Juniata and Susquehanna Rivers. The character and water-bearing properties of these formations are described in the first part of this report. Cove, Peters, Berry, and Buffalo Mountains are formed by the Pocono formation, and the remainder of the high ridges that border the county on the north, south, and west are formed by the Tuscarora quartzite. The folds trend northeast, and the two synclines that have preserved the Mauch Chunk shale pitch downward toward the east, where they unite to form the Southern Anthracite field of Dauphin and Schuylkill Counties. The structure in the south-central part of the county is characterized by complex folds and by several faults. The absence of late Silurian and Lower Devonian strata at the Susquehanna Water Gap south of Marysville may be due to a fault or to an unconformity.⁹⁰

GROUND WATER

In Perry County ground water is used chiefly for domestic or stock supply. Small springs are numerous, owing to the mountainous nature of the county, and are used by many of the farms, but no large springs were observed. Dug wells appear to be more numerous than drilled wells. The farm wells tap many different geologic formations, and most of them yield adequate supplies, but a few, such as well 844, do not yield sufficient water.

Relatively few wells are used for industrial or public supply. Two wells in Newport yield 80 and 85 gallons a minute (nos. 823,

⁹⁰ Willard, Bradford, Oriskany at Susquehanna Gap, Pa.: Geol. Soc. America Bull., vol. 42, pp. 697-706, 1931.

824), and two in Duncannon yield 30 and 40 gallons a minute (nos. 839, 840). Well 814, in Elliotsburg, was reported to yield about 160 gallons a minute, but the plant which it supplied is now closed. Two wells near Loysville yield more than 25 gallons a minute. The condensing plant of the Breyer Ice Cream Co., across the Juniata River from Millerstown, uses about 300,000 gallons of water a day, obtained from springs near the base of Raccoon Ridge. This is the largest ground-water supply observed in the county.

Only three flowing wells (nos. 790, 812, 833) were observed, but one other was reported near Erly. It is possible that other flowing wells could be obtained by deep drilling in some of the synclinal basins, such as The Cove, Hunters Valley, and some of the valleys in the southwestern part of the county.

Weekly measurements of the depth to water level in wells 782 and 822 are being made. (See pp. 35-39.) A view of well 822 is shown in plate 8.

Five analyses of ground water from as many geologic formations in Perry County are tabulated below, and the quality of water to be expected from the different formations is summarized on pages 80-81. These analyses indicate moderately hard to very hard waters, and three show more than 0.1 part per million of iron. The hardest water analyzed came from well 801, in the Wills Creek shale of the Cayuga group, and it is possible that some of the waters from the calcareous part of the Cayuga group may have even greater hardness. In general, however, the ground waters in Perry County are satisfactory for most ordinary purposes.

PUBLIC SUPPLIES

Marysville, Duncannon, and Newport, the three largest boroughs in the county, are supplied by surface water, and Juniata Bridge and Benvenue are supplied from Duncannon. Several Civilian Conservation Corps camps in Toboyne Township are also supplied by surface water. Blain, Millerstown, Bloomfield, and the Tressler Orphans' Home at Loysville are supplied by ground water.

Blain (population 291) is supplied by the Blain Water Co. from a spring that issues from sandstone at the foot of Conococheague Mountain, about a mile northwest of the borough. The water is stored in a 60,000-gallon concrete reservoir below the spring and is distributed by gravity. The reservoir is reported to overflow continuously in normal weather. There are 13 fire

hydrants in the system, and about 100 homes are supplied. The water does not require treatment.

Millerstown (population 689) is supplied by the borough from three springs that issue from a red sandstone of the Clinton formation on the north slope of Tuscarora Mountain, in Juniata County, about 3 miles northwest of the borough. The springs are reported to yield an aggregate of about 38 gallons a minute. The water flows by gravity to a 220,000-gallon concrete reservoir on a hill just north of the borough line and is distributed by gravity at pressures ranging from 95 to 110 pounds to the square inch. There are 10 fire hydrants in the system, and about 750 people are supplied. The water does not require treatment.

Bloomfield (post office New Bloomfield; population 730) is supplied by the Bloomfield Water & Sewer Co. from about 10 small springs that issue from sandstone of the Oriskany group on Limestone Ridge, half a mile east of the borough. The aggregate yield of the springs is about 60 gallons a minute (spring 815). The water is stored in two concrete reservoirs just north of the borough, having a total capacity of 175,000 gallons, and is distributed by gravity at an average pressure of about 39 pounds to the square inch. There are 14 fire hydrants in the system, and about 210 families are supplied. The water does not require treatment and is of good quality except for its hardness, as shown by analysis 815.

The Tressler Orphans' Home, near Loysville, is supplied most of the time from two springs that issue from the Helderberg limestone on Limestone Ridge, 1½ miles northeast of the home. The water is stored in two concrete reservoirs holding an aggregate of 220,000 gallons and in a 100,000-gallon fire tank, whence it is distributed by gravity at an average pressure of 30 pounds to the square inch. There are two auxiliary drilled wells for use only when the spring supply is inadequate (wells 801, 802), one of which was being pumped when the home was visited in August 1934. Water from the wells is pumped to the reservoirs by a separate booster pump. There are 11 fire hydrants at the home. The daily consumption ranges from 24,000 to 30,000 gallons. The spring water is chlorinated; the well water is not. The well water is very hard, as shown by analysis 801.

Typical wells and springs in Perry County

No. on pl. 2	Location	Owner or name	Topographic situation	Altitude (feet)	Type of supply ^b	Depth (feet)	Diameter (inches)	Principal water-bearing bed		Length of casing (feet)	Depth to water level (feet)	Method of lift ^c	Yield (gallons a minute)	Use of water ^d	Remarks
								Character of material	Geological horizon						
777	Liverpool Township	John F. Decker	Valley	400	Dr	66	6	Hard blue sandy shale	Chemung.....	12	?	H	3±	D	Reported draw-down 10 feet at 10 gallons a minute. Reported draw-down about 16 feet at 15 gallons a minute. U. S. Geological Survey observation well; see pp. 35-39. Reported draw-down 20 feet at 4 gallons a minute.
778	2.8 miles northeast of Liverpool	A. E. Aucker	Slope	440	Dr	60	6	Red shale.....	Catskill.	30	20±	H	5±	D	
779	0.1 mile north of Berlee	H. E. Rubendall	do.	540	Dr	62	6	do.	do.	20	20±	H	3±	D, S	
780	Greenwood Township	Robert McDonald	Knoll	560	Dr	124	6	Blue shale.....	Wills Creek...	12	30±	H	10±	D	
781	0.9 mile south of Nekoda	Ivan Zeigler	Valley	450	Dr	41	6	Red and blue shale	do.	26	10±	H	15±	D	
782	1.9 miles northeast of Millerstown	I. L. Zeigler	Slope	460	Du	12.5	4.8±	Shale.....	Cayuga.....	12.5	2.8 to 5.5	N	(?)	N	Reported draw-down 20 feet at 4 gallons a minute.
783	2.7 miles northeast of Millerstown	Charles Lidick	Ridge	660	Dr	100	6	do.	Chemung.....	20	30±	H	4±	D	
784	2.1 miles east of Millerstown														
785	Tuscarora Township	Dr. Gearhard	Hillside	560	Dr	70	6	(?)	Cayuga.....	(?)	?	H	(?)	D, S	Reported draw-down about 18 feet at 20 gallons a minute. Water reported to contain hydrogen sulphide.
786	1.4 miles west of Millerstown	W. R. Reynolds	Valley	500	Dr	50	6	(?)	Helderberg or Tonoloway	(?)	?	H	(?)	D	
787	Donnelly Mills														
788	Saville Township	Thomas Nelson	do.	560	Dr	50	6	Black and blue shale	Portage.....	14	1±	H	20±	D	Reported draw-down about 20 feet at 3 gallons a minute. Reported to flow a small amount. One other flowing well reported nearby.
789	Eschol	Clarence Swartz	do.	620	Dr	16	6	"Hardpan"	Wills Creek...	14	4±	H	1-2	D	
790	Lekesburg	Dr. G. S. Kinzer	do.	640	Dr	47	6	Limestone	do.	18	?	H	3±	D	
791	do.	Mrs. Schull	Slope	620	Dr	60	6	Hard lime- stone	do.	22	20±	H	3±	D	
792	Erly	G. R. Lightenct	do.	630	Dr	51.5	6	Gray shale....	Portage.....	21.5	+ ?	H	3±	D	

791	1.2 miles north of Greenpark	Josiah Dunn.....	Hillside	870	Dr	127	6	Limestone.....	Helderberg.....	50	?	P	10	D,S
	Madison Township													
792	Bixler.....	G. E. Beek.....	Valley	620	Dr	42	6	do.	Tonoloway or Wills Creek	29.5	?	H	10±	D
793	0.1 mile south of Kistler	E. M. Dobbs.....	Slope	680	Dr	35	5	Black shale...	Hamilton or Marcellus	24	15±	H	3±	D,S
794	0.2 mile northeast of Stony Point	David Boltser.....	Hillside	840	Dr	85	6	(?)	Helderberg...	(?)	?	H	(?)	D,S
	Jackson Township													
795	1.7 miles west of Andersonburg	Stambaugh Bros.....	Canyon	860	Dr	150	6	Limestone.....	Helderberg or Tonoloway	17	?	H	1±	D,S
796	1.7 miles southwest of Andersonburg	Luke Flekinger.....	Valley	680	Dr	51	6	Yellow sand- stone	Wills Creek...	7	?	H	12+	S
797	Mount Pleasant.....	Paul McKean.....	Slope	.....	Dr	43	6	Red and blue shale	do.	18	15±	H	3±	D
	Toboyne Township													
798	2.2 miles southwest of New Germantown	E. C. Adams.....	Slope	.....	Dr	70	6	Red shale.....	Clinton.....	18±	15±	H	5+	D,S
799	3.4 miles southwest of New Germantown	Lee O'Donnell.....	do.	.....	Dr	96	6	Yellow shale	do.	26	35±	H	2±	D
800	Monterey.....	Dr. R. S. Dorset.....	Hillside	.....	DD	104	6	Red shale.....	do.	22	20±	H,P	5	D
	Tyrone Township													
801	0.6 mile north of Loysville	Tressler Orphans' Home	Slope	620	Dr	308	6	Red and gray shale	Wills Creek...	38	21	P	25+	P
802	0.2 mile north of Loysville	do.	Valley	570	Dr	102	6	Shale.....	do.	?	10±	P	25+	P
803	0.8 mile south of Loysville	James Morrow.....	Slope	600	DD	44	6	do.	do.	17	15±	H	3±	D
804	1.1 miles south of Loysville	Harrisburg Boy Scout Camp	do.	580	Dr	95	6	Red shale.....	Bloomsburg...	45	20±	P	12±	D
805	Greenpark.....	Greenpark School...	do.	610	Dr	61	6	Shale.....	Wills Creek...	45	20±	H	10±	D
806	1 mile north of Landisburg	D. Rice.....	Hillside	650	Dr	125	6	do.	do.	75	?	H	5±	I
807	0.5 mile north of Landisburg	Roy Neely.....	Canyon	700	Dr	128	6	Limestone.....	Helderberg or Tonoloway	90.5	90±	H	6±	D
808	Landisburg.....	E. S. Rice.....	Slope	560	Dr	112	6	Brown and red shale	Wills Creek...	67	20±	P	5±	D

Water reported in yellow sandstone
above limestone.Reported draw-down 10 feet at 5
gallons a minute.Reported draw-down 30 feet at 5
gallons a minute. Pump set 10
feet below surface in dug part of
well.Reported draw-down 5 feet on bail-
ing more than 30 gallons a min-
ute. Temperature 53°F. See
analysis.Reported draw-down about 5 feet
after 16-hour bailing test at
probably more than 25 gallons a
minute. Auxiliary supply.Reported tested at 12 gallons a
minute.

Typical wells and springs in Perry County—Continued

No. on pl. 2	Location	Owner or name	Topographic situation	Altitude (feet) ^a	Type of supply ^b	Depth (feet)	Diameter (inches)	Principal water-bearing bed		Length of casing (feet)	Depth to water level (feet)	Method of lift ^c	Yield (gallons a minute)	Use of water ^d	Remarks
								Character of material	Geologic horizon						
809	Landisburg.....	Charles Burtnett.....	Slope	570	Dr	100	6	Red and gray shale	Wills Creek ..	27	27±	P	5+	D	Reported small draw-down at 12 gallons a minute.
810	2.5 miles southwest of Bridgeport	Com. T. Morrison.....	Hillside	680	Dr	86	6	Red shale and sandstone	do.	45	20±	H	5+	D,S	Reported tested at 15 gallons a minute.
811	Spring Township	Jack Snyder.....	Valley	500	Dr	80	6	Shale.....	Helderberg...	(?)	?	H	3±	D	
812	1.8 miles southeast of Bridgeport	Frank Spotts.....	Slope	530	Dr	400	15	Red sandstone and shale	Wills Creek...	40	+	F	1±	N	Abandoned oil test. Observed flow- ing a small amount on August 29, 1934.
813	Elliottsburg.....	W. H. Gray.....	do.	680	Dr	37	6	Limestone.....	do.	15±	4±	H	3±	D	Red shale overlies limestone. Local wells ending in red shale re- ported to yield soft water.
814	do.	Hershey Ice Cream Co. (former owner)	Valley	660	Dr	247	6	Red and blue shale	do.	18	8±	S	160±	N	Reported draw-down 4 feet on pumping 160 gallons a minute indefinitely. Plant shut down.
815	Center Township	Bloomfield Water & Sewer Co.	Canyon	750	10 Sp	.....	.....	Sandstone.....	Oriskany.....	.....	.....	F	60±	P	Aggregate yield of 10 small springs. Temperature 52°F. See analysis.
816	0.5 mile west of Bloomfield	Harry Hoffman.....	Valley	530	Dr	70	6	Red shale.....	Catskill.....	16	8±	H	5+	D	Reported draw-down 12 feet at 20 gallons a minute.
817	Walnut Grove.....	Earl Walker.....	do.	500	Dr	115	6	do.	do.	12	20±	H	3	D	Tight red sandstone overlies red shale.
818	0.2 mile north of Markelsville	Robert Fosselman.....	Hillside	480	DD	140	6	Red sandstone	do.	20	40±	H,P	5±	D,S	Red sandstone forms crest of ridge.
819	Wila.....	David George.....	Ridge	740	DD	90	6	Red and blue shale	Catskill or Chemung	20	25±	H	3+	D	Reported draw-down 10 feet at 3 gallons a minute.

820	Oliver Township 1.1 miles west of Newport	Joseph Jones.....	Ridge	740	Dr	65	6	Red and blue shale	Catskill or Chemung	(?)	?	H	3±	D	Red and blue sandstone overlies shale.
821	0.6 mile north of Newport	Mrs. Hostetter.....	Valley	390	Dr	68	6	Red sandstone	Catskill.....	20	13±	H	6	D	Reported draw-down about 10 feet at 6 gallons a minute.
822	do.	Miss Bertha Demaree	do.	400	Du	19.5	48±	Soil.....	Weathered Chemung.....	19.5	8.8 to 17.8	N	?	N	U. S. Geological Survey observation well; see pp. 35-39 and pl. 8.
823	do.	Forged Steel Products Co.	Slope	420	Dr	270±	6	Sandstone or shale	do.	(?)	?	P	85±	D,I	
824	do.	Carlisle Hygienic Ice Co.	Valley	380	Dr	300	8	Red sandstone	do.	25	25±	T	80	C	Reported draw-down 100 feet at 100 gallons a minute. Water contains hydrogen sulphide. Tem- perature 54°F. See analysis.
825	0.1 mile southwest of Newport	Frank Snyder.....	do.	400	Dr	19	6	Sandstone?	do.	18	5±	H	2±	D	
826	Howe Township 1.2 miles south of Acker	E. D. Thomas.....	do.	390	Dr	94	6	(?)	Portage.....	(?)	22±	P	5	D	
827	Watts Township New Buffalo	R. L. Hilbish.....	do.	380	Dr	53	6	Red shale.....	Catskill.....	(?)	?	H	3±	D	
828	Amity Hall.....	W. B. Brown.....	do.	360	Dr	120	6	(?)	do.	(?)	30±	H,P	3	D	
829	Miller Township 0.4 mile north of Losh Run	Roy Blizzard.....	do.	360	Dr	50	6	Red shale?.....	Hamilton.....	20	10±	H	3±	D	Hard sandstone overlies red shale.
830	0.5 mile northwest of Losh Run	J. R. Johnston.....	Hillside	480	Dr	62	6	Gray shale.....	do.	(?)	30±	H	3±	D	
831	Wheatfield Township 0.2 mile northeast of Aquetuet	Dr. Oenslager.....	Valley	360	Dr	63	6	Red and blue shale	Catskill.....	26	30±	W	5±	D	
832	1 mile east of Dellville	K. E. Shearer.....	Hilltop	590	Dr	119	6	Red sandstone and shale	do.	4	30 to 50	H	3±	D,S	
833	Carroll Township 0.2 mile north of Dromgold	Charles Duncan.....	Slope	470	Dr	23±	6	Sandstone or shale	Chemung.....	8	+3±	H	3±	D,S	Flows about 1 galloo a minute. Water contains hydrogen sulphide.
834	0.4 mile south of Dromgold	John Stone.....	do.	480	Dr	110	6	Sandstone.....	do.	20±	30±	H	3±	D,S	
835	Shermanvale.....	Bob White Inn.....	do.	450	Dr	70	6	Red shale.....	Catskill.....	7	?	P	3±	D	
836	1.4 miles northwest of Sterrett Gap	B. Nieky.....	do.	740	Dr	109	6	(?)	Hedderberg or Tonoloway	45	?	H	3±	D	
837	0.9 mile northwest of Sterrett Gap	Mrs. Minnie Ganister	do.	680	Dr	70	6	Shale.....	Wills Creek...	21	?	H	18±	D	
838	Sterrett Gap.....	Dr. Stay.....	Saddle	940	Dr	43	6	Hard ss.....	Tuscarora.....	20	?	H	3±	D	

Typical wells and springs in Perry County—Continued

No. on pl. 2	Location	Owner or name	Topographic situation	Altitude (feet) ^a	Type of supply ^b	Depth (feet)	Diameter (inches)	Principal water-bearing bed		Length of casing (feet)	Depth to water level (feet)	Method of lift ^c	Yield (gallons a minute)	Use of water ^d	Remarks
								Character of material	Geologic horizon						
839	Penn Township Duncannon.....	Duncannon Borough Light Co.	Slope	370	Dr	338	8	Red shale.....	Catskill.....	(?)	?	T	30	C	Temperature 54° F. See analysis. Do. Pumps nearly dry in 1 hour with windmill operating.
840	do.	Supplee-Wills-Jones Milk Co.	Valley	350	Dr	330	6	Red shale or sandstone	do.	(?)	?	P	40	C	
841	1.3 miles southwest of Kinkora Heights	J. W. C. Kugler.....	do.	440	Dr	66½	6	Red shale.....	Mauch Chunk	15±	12±	H	3±	D	
842	0.7 mile southwest of Kinkora Heights	Middle Cove Union Sunday School	do.	410	Dr	71	6	do.	do.	(?)	?	H	1±	D	
843	0.5 mile west of Cove	C. J. Ellenberger....	do.	360	Dr	76	6	do.	do.	22	10±	H	3±	D	
844	Rye Township Keystone.....	A. M. Kellar.....	Knoll	600	Dr	110	6	Red sandstone	Catskill.....	(?)	50±	H, W	1±	D, S	

^a Altitudes taken from nearest contour on topographic maps. No topographic map of western part of county.

^b Dr, drilled well; Du, dug well; DD, dug and drilled well; Sp, spring.

^c F, natural flow; H, lift pump, hand-operated; N, none; P, force pump, power-operated; S, suction pump, power-operated; T, turbine pump; W, windmill.

^d C, condensing or cooling; D, domestic; I, industrial; N, none; P, public supply; S, stock.

Analyses of ground waters from Perry County

[Analyzed by E. W. Lohr. Parts per million. Numbers at heads of columns refer to corresponding numbers in the preceding table and on pl. 2.]

	801	815	824	840	843
Silica (SiO ₂).....				12	
Iron (Fe).....	0.07		0.22	.18	0.27
Calcium (Ca).....	73	56	46	27	50
Magnesium (Mg).....	32	5.8	13	13	9.7
Sodium (Na).....	a b	a b	a 26	15	a 2
Potassium (K).....				3.2	
Bicarbonate (HCO ₃).....	258	168	144	96	120
Sulphate (SO ₄).....	85	c 10	81	28	c 20
Chloride (Cl).....	4.0	1.5	15	19	32
Nitrate (NO ₃).....	9.0	8.4	.50	18	5.0
Total dissolved solids.....	a 335	a 170	a 252	193	a 178
Total hardness as CaCO ₃ (calculated)...	314	164	168	121	165
Date of collection (1934).....	Aug. 25	Aug. 29	Aug. 28	Aug. 27	Aug. 27

^a Calculated.

^b Less than 5 parts.

^c By turbidity.

SNYDER COUNTY

Area 311 square miles. Population (1930) 18,836.

GEOGRAPHY

Snyder County is just 6 square miles larger than Union County, the smallest county in the area. It ranks sixth in density of population, with about 61 inhabitants to the square mile, as compared with 215 for the entire State. Selinsgrove and Middleburg, with 2,797 and 1,024 inhabitants respectively in 1930, are the only boroughs in the county having as many as 1,000 people. Agriculture is the principal occupation, and 70 percent of the total land area is devoted to farming—a greater percentage than in any other county covered by this report. The Federal census of 1929 credits the county with 42 manufacturing establishments whose products are valued at \$5,000 or more annually. The Susquehanna Trail parallels the Susquehanna River along the eastern boundary, and a branch line of the Pennsylvania Railroad traverses the county westward from Selinsgrove to Lewistown. The Reading Railroad crosses the northeast corner.

The topography in Snyder County is typical of the Ridge and Valley province. The highest known point is on Shade Mountain, which rises to an altitude of 2,060 feet in Spring Township, but it is possible that a higher point may exist on Jacks Mountain, in the northwestern part of the county, as that section has not been mapped topographically. The Susquehanna River leaves the county at an altitude of about 380 feet—the lowest point in the county. The maximum known relief is therefore about 1,680 feet. The highest part of Shade Mountain stands about 1,400 feet above the adjacent valleys. Except for small areas in West Perry and West Beaver Townships that are drained by tributaries of the Juniata River, Snyder County is drained entirely by the Susquehanna River, which forms the eastern boundary.

GEOLOGY

The Paleozoic rocks exposed in Snyder County range from the Reedsville shale, of Upper Ordovician age, exposed along Shade and Jacks Mountains (oldest), to the Catskill formation, of Upper Devonian age, exposed north of Port Trevorton and westward from Northumberland. There is believed to be no marine Chemung in Snyder County. Pleistocene deposits of Jerseyan, Illinoian, and Wisconsin age are found in the northern part of the county and along the Susquehanna River. The Illinoian terminal moraine ends in the vicinity of Selinsgrove (pl. 1). The character and water-bearing properties of these formations are described in the first part of this report.

The four major folds trend northeastward and are known from north to south as the Montour anticline, Northumberland syncline, Selinsgrove anticline, and Shamokin syncline.

GROUND WATER

The principal settlements and most prosperous farms in Snyder County are in the fertile valleys underlain by the Cayuga group (see pl. 1), where wells drilled for domestic, industrial, or public supply generally obtain moderate to large amounts of water. The Helderberg and Tonoloway limestones and the limestones of the Wills Creek shale are probably the most productive water-bearers in the county. Four wells in Selinsgrove and vicinity (nos. 354, 355, 356, and 358) were reported to yield 50 to 125 gallons a minute, and well 363 in Middleburg was reported to yield 60 gallons a minute. The Middle and Upper Devonian rocks form hilly areas devoted principally to farming and generally yield small but adequate supplies for domestic or stock use. The Clinton and older formations form the high ridges, on which there is very little development.

So far as is known, no attempts have been made to obtain water from the Pleistocene deposits, although sand and gravel in considerable thickness have been cased off in some of the wells along the Susquehanna River. In some wells near Selinsgrove (see pp. 119-121), however, only a thick bed of clay was encountered. In wells 344, 348, 352, 354, 355, 356, 357, and 381 from 24 to 90 feet of unconsolidated material was cased off.

Dug wells are still used extensively in the rural regions and constitute the principal source of water in many of the smaller settlements, such as Centreville, Kantz, and Benfer. In Freeburg, Kratzerville, and many hilly areas drilled wells predominate; in Port Trevorton small springs form the principal source of supply.

The only flowing well reported in Snyder County is well 370, which is reported to flow only in the winter. The water in well 373 rises to the surface in the winter but does not overflow.

The analyses of 5 samples of ground water from as many formations in Snyder County are given below, and the quality of water to be expected from the different formations exposed in the county is summarized on pages 80-81. The analysis of water from well 345, in the Hamilton formation, shows a large amount of iron, and this condition was reported in several other nearby wells, but none of the other samples contained as much as 0.1 part per million of iron. Most of the samples were slightly or only moderately hard, but the sample from well 358, in the

Cayuga, had a hardness of 205. It is quite possible that some of the Cayuga waters are excessively hard, as they are in parts of Bedford, Mifflin, Union, and Northumberland⁹¹ Counties. Most of the waters, however, are reported to be satisfactory for ordinary purposes.

PUBLIC SUPPLIES

Selinsgrove, Middleburg, McClure, and Beaver Springs are supplied with surface water, and Mount Pleasant Mills, Troxelville, and the Selinsgrove State Colony for Epileptics are supplied with ground water.

Mount Pleasant Mills is supplied from a spring (no. 374) and an auxiliary drilled well (no. 373), owned by J. Calvin Boyer, a resident. The water is stored in a 2,000-gallon covered masonry reservoir, and is distributed by gravity at pressures ranging from 11 to 35 pounds to the square inch. The spring generally furnishes all the water needed, but when required water from the well is pumped directly into the distributing mains, the excess backing up into the reservoir. The average daily consumption is about 3,000 gallons. The water from both sources is treated with chloride of lime. The spring yields a good, moderately hard water, as shown by analysis 374.

Troxelville is supplied by the Troxelville Water Co. from three small springs (no. 333). The water flows into a 10,500-gallon covered concrete reservoir and is distributed by gravity at pressures ranging from 70 to 80 pounds to the square inch. There are nine 1-inch fire hydrants and about 25 or 30 families are supplied. The water requires no treatment and is a good soft water, as shown by analysis 333.

The Selinsgrove State Colony for Epileptics, 1 mile northwest of Selinsgrove, is supplied from three drilled wells (nos. 354-356). A considerable quantity of water is used, but no data were obtained regarding the daily consumption or the method of storage and distribution.

⁹¹Lohman, S. W., Ground water in northeastern Pennsylvania: Pennsylvania Geol. Survey, 4th ser. Bull. W 4, p. 204, 1937.

Typical wells and springs in Snyder County

No. on pl. 2	Location	Owner or name	Topographic situation	Altitude (feet) ^a	Type of supply ^b	Depth (feet)	Diameter (inches)	Principal water-bearing bed		Length of casing (feet)	Depth to water level (feet)	Method of lift ^c	Yield (gallons a minute)	Use of water ^d	Remarks
								Character of material	Geologic horizon						
325	West Beaver Township 1.3 miles north of Cross Grove	Mrs. H. C. Ulsh.....	Hillside	850±	Dr	85	6	Limestone....	Helderberg....	41	?	H	3-5	D,S	
326	1.1 miles north of Cross Grove	Charles Wagner.....	do.	810	Dr	68	6	do.	Onondaga?...	25	25±	H	3-5	D	
327	0.3 mile north of Cross Grove	Ira W. Bickle.....	Valley	720	Dr	70	6	Shale?.....	Portage.....	(?)	?	H	3±	D	
328	Bannerville.....	Mr. Narehood.....	Knoll	720	DD	71	6	Black shale....	do.	30	33±	H	4	D	
329	0.2 mile south of McClure	Bruce Gramly.....	Slope	760	Dr	66	6	Soft shaly limestone	Wills Creek....	30	33±	H	3-5	D	
330	1.5 miles northwest of Raubs Mills	C. H. Dreese.....	do.	660	Dr	32	6	Hard blue sandstone	Hamilton.....	(?)	25±	H	3±	D	Water reported hard.
331	Spring Township 1.4 miles west of Beaver Springs	W. J. Treaster.....	do.	700±	Dr	95	6	Flinty lime- stone	Onondaga?...	26	27±	H	5±	D,S	Driller's location not checked.
332	Benfer.....	Charles Troxel.....	do.	.....	DD	35	6	Black shale..	Portage.....	15	7±	H	3-5	D	Water reported to contain hydrogen sulphide.
333	Adams Township 0.6 mile north of Troxelville	Troxelville Water Co.	Hillside	.....	3 Sp	.....	.....	Yellow sand- stone	Clinton.....	.....	.....	F	10-20	P	Aggregate yield of 3 springs about 10 gallons a minute, August 1934, but reported to be about 20 gal- lons in winter. See analysis of composite sample.
334	Centre Township 2.6 miles southwest of Centreville (Penns Creek)	J. F. Bingham.....	Low ridge	.....	Dr	77	6	Limestone....	Helderberg or Tonoloway	40	30±	H	5+	S	
335	Centreville.....	M. E. Walter.....	Valley	.....	Dr	68	6	Hard blue shale	Wills Creek....	30	12±	H	3-5	D	Other wells in Centreville reported to be about the same depth.

336	Jackson Township 0.6 mile south of New Berlin	Miles Walker.....	Hillside	560	Dr	71	6	Gray sandstone	Hamilton.....	28	28±	P	12	D,S	Reported draw-down 18 feet at 12 gallons a minute. Formerly supplied silk mill.
337	Kratzerville.....	H. M. Derk.....	Ridge	670	Dr	120	6	Hard red sandstone	Catskill.....	25	24±	N	10+	N	
	Monroe Township														
338	0.6 mile northeast of Kratzerville	C. A. Schweitzer.....	Valley	460	Dr	57	6	Red sandy shale	do.	23	9±	H	5±	D	Reported draw-down 3 feet at 15 gallons a minute.
339	1.6 miles east of Kratzerville	Ernest Bailey.....	Ridge	750	Dr	101	6	Hard gray sandstone	do.	10	10±	P	4	D,S	
340	1.7 miles south of Winfield	D. S. Hess.....	do.	790	DD	61	6	Red sandstone	Catskill.....	27	18±	P	12	S	Reported draw-down about 10 feet at 12 gallons a minute.
341	0.2 mile north of Shamokin Dam	Sandy Beach Improvement Co.	Valley	440	Dr	66	6	Black sandy shale	Portage?.....	29	19±	H	5±	D	Reported draw-down 10 feet at 15 gallons a minute.
342	Shamokin Dam.....	T. A. Trexler.....	do.	440	Dr	76	6	Black shale.....	do.	24	18±	S	5	D	Reported draw-down 6 feet at 10 gallons a minute.
343	do.	Pennsylvania Power & Light Co.	do.	460	Dr	33	6	Hard blue sandstone	Hamilton.....	18	?	H	1±	D	Reported large draw-down on pumping 5 gallons a minute for 10 minutes, 18 feet of gravel cased.
344	do.	William Gouglar.....	do.	470	Dr	75	6	do.	do.	24	10±	H	5±	D	Reported tested at 20 gallons a minute. 24 feet of gravel cased.
345	do.	Mrs. Maude Park....	Slope	480	Dr	73	6	Black shale.....	do.	54	15±	S	4	D	Water contains excess iron; see analysis. Temperature 55°F. Well deepened from 54 feet and casing increased.
346	0.5 mile north of Hummells Wharf	Lee Bottiter.....	Hillside	530	Dr	110	6	Gray sandstone	do.	21	27±	S	5	D	Reported draw-down 2 feet on pumping 5 gallons a minute continuously.
347	Hummells Wharf	Monroe Realty Co....	Valley	450	Dr	79	6	Hard black shale	Marcellus....	28	18±	H	5±	D	Reported draw-down 4 feet at 10 gallons a minute.
348	1 mile southwest of Hummells Wharf	Shamokin Dam Water Co.	do.	450	Dr	251	6	Solid limestone	Helderberg or Tonoloway	88	50±	P	13	N	Drilled to supply Hummells Wharf, but system never completed. 26 feet of sand and gravel and 62 feet of clay cased. Water reported to come from depth of 200 feet.
	Penn Township														
349	1.2 miles southeast of Kratzerville	Amon O. Kline.....	do.	480	Dr	45	6	Yellow shale..	Portage?.....	15.7	16±	H	5±	D	Reported draw-down 26 feet on pumping about 8 gallons a minute.
350	1.7 miles west of Hummells Wharf	W. P. Kembley.....	do.	460	Dr	40	6	Gray sandstone	Hamilton.....	27	8±	H	5±	D	Reported draw-down 13 feet at 15 gallons a minute.
351	0.8 mile north of Salem	Charles Kenny.....	Canyon	550±	Dr	39	6	Hard gray "rock"	do.	23.5	12±	H	4-	D,S	Reported draw-down 12 to 15 feet at 4 gallons a minute. Water reported to contain hydrogen sulphide. Lumps of iron pyrite encountered.
352	Salem.....	Harvey F. Keefer.....	Hillside	640	Dr	113	6	Limestone.....	Wills Creek...	60	83±	P	6.5	D	60 feet of clay, sand, and gravel cased.
353	0.6 mile south of Salem	Dairymen's League Cooperative Assn.	Slope	560	Dr	160	6	do.	do.	90	?	P	(*)	N	Plant shut down. 90 feet of clay cased.

Typical wells and springs in Snyder County—Continued

No. on pl. 2	Location	Owner or name	Topographic situation	Altitude (feet) ^a	Type of supply ^b	Depth (feet)	Diameter (inches)	Principal water-bearing bed		Length of casing (feet)	Depth to water level (feet)	Method of lift ^c	Yield (gallons a minute)	Use of water ^d	Remarks
								Character of material	Geological horizon						
354	0.9 mile southeast of Salem	Selingsgrove State Colony for Epileptics do.	Knoll	600	Dr	150	10	Limestone . . .	Wills Creek . . .	65	61±	P	50	P	Well 1. Reported tested at 200 gallons a minute.
355	do.		do.	600	Dr	150	10	Shaly lime- stone	do.	65	67±	T	100	P	Well 2, 100 yards west of No. 1. Reported draw-down 12.3 feet at 100 gallons a minute. Reported tested at 225 gallons a minute.
356	do.	do.	do.	600	Dr	225	10	Sandstone? below lime- stone	do.	70	69±	T	125	P	Well 3, 200 yards northeast of No. 1. Reported draw-down 3.37 feet at 150 gallons a minute. Some water at 150 feet in limestone; most water reported in sandstone? be- tween 200 and 225 feet. 26 feet of gravel cased.
357	Selingsgrove	Mr. Meas	Valley	450	Dr	64	6	Shaly lime- stone	do.	40	20±	H	8±	D	No appreciable draw-down reported. Water makes clear ice. Tempera- ture 54° F. See analysis.
358	do.	Crystal Pure Ice Co., Charles W. Kellar	do.	440	Dr	47.5	10	Limestone . . .	Topoloway or Wills Creek	10	5±	C	125	C, I	Emergency supply only. Uses city water.
359	do.	W. F. Gross Silk Mill	do.	450	Dr	101	6	do.	Wills Creek . . .	60	40±	P	13±	I	
360	0.1 mile north of Kantz	G. E. Rishel	do.	440	Dr	46	6	Red shale . . .	do.	20	20±	H	3±	D	
361	Middle Creek Twp. 0.1 mile west of Kreamer	William Dunkleberger	Hillside	510±	Dr	40	6	Calcareous shale	do.	23.7	18±	H	5±	D	Driller's location not checked. Re- ported draw-down 12 feet at 15 gallons a minute.
362	Franklin Township 1 mile northwest of Middleburg	Reading Rendering Co.	Canyon	.....	Dr	50	6	Blue shale . . .	Portage	20	10±	S	6-7	I	
363	0.5 mile east of Middleburg	Sheffield Farms, Inc. . .	Valley	.....	Dr	151	8	Limestone . . .	Wills Creek . . .	30	25±	P	60	C	Reported draw-down about 1 foot on pumping 60 gallons a minute for 24 hours.
364	do.	Dairymen's League Cooperative Assn.	do.	.....	Dr	85	6	do.	do.	20	40±	P	30	N	Plant shut down.

	do.	.....	Dr	60	6	Red shale.....	do.	40	30±	H	3-5	N	Uses public water supply.
365 0.7 mile east of Middleburg Beaver Township	L. H. Kellar.....	.....	Dr	158	10	Crevice limestone	Tonoloway or Wills Creek	60	50±	P	9	D, I	Field location on inaccurate map; may be in Franklin Township. Reported draw-down 5 feet on pumping 150 gallons a minute for 24 hours. Water-bearing crevices at 60 feet and below.
366 2.2 miles west of Paxtonville	J. C. Stahl estate.....	Slope	Dr										
367 do.	do.	do.	Dr	68	6	Limestone.....	do.	(?)	?	P	6±	D	Field location on inaccurate map; may be in Franklin Township. Uses public water supply.
368 Beavertown.....	Frank Beaver.....	Valley	Dr	80	8	do.	Wills Creek...	(?)	?	H	3-5	N	
369 do.	C. Schrader.....	do.	Dr	51	6	do.	do.	20	20±	H	3-5	D, S	
West Perry Township													
370 0.5 mile east of Richfield	Amon Reichenbach.....	do.	Dr	55	6	do.	Helderberg...	18	+ to 15	H	3-5	D	Reported to flow a small amount in winter. Several clay seams cased.
371 1.5 miles northeast of Richfield	J. O. Pellman.....	Slope	Dr	73	6	do.	Wills Creek...	63	53±	H	1.5	D	
372 Stroutstown.....	Mrs. Frank Hoffman.....	Saddle	Dr	62	6	Gray shale.....	Hamilton.....	18	30±	H	1	S	
Perry Township													
373 Mount Pleasant Mills (Fremont)	John Calvin Boyer.....	Slope	Dr	79	6	Limestone.....	Onondaga? or Helderberg	25	0 to 18±	P	5	P	Auxiliary public supply. Reported draw-down 10 feet at 5 gallons a minute.
374 0.2 mile west of Mount Pleasant Mills	do.	do.	Sp	620	.....	do.	Onondaga?.....	.....	.....	F	2+	P	Maximum yield more than yield indicated. Temperature 60°F. See analysis.
375 1.5 miles east of Stroutstown	Stewart S. Teats.....	Hillside	Dr	60	6	Blue shale.....	Hamilton.....	16	10±	H	7.5	S	
376 1.4 miles southeast of Stroutstown	do.	Valley	Dr	42	6	do.	Portage?.....	14	22±	H	1±	D	
Washington Township													
377 1.2 miles southeast of Kremer	John Boyer.....	Ridge	DD	112	6	do.	Clinton.....	32±	30±	H	3±	D	
378 1.4 miles southeast of Kremer	do.	do.	Dr	52	6	Hard brown sandstone	do.	(?)	11±	H	5±	D	Reported small draw-down at 25 gallons a minute.
379 Freeburg.....	Freeburg Silk Mill, (Mrs. E. R. Winger)	Slope	Dr	100	6	Limestone.....	Wills Creek...	30	40±	P	10	I	
380 do.	W. S. Hoover.....	do.	Dr	64	6	do.	do.	32	32±	P	2	D	
Union Township													
381 Hoover Island..... (Northumberland Co.)	Mr. Seiler.....	Island	Dr	45	6	Red sandstone	Catskill.....	30	25±	H	4	D	At north end of island, 30 feet of sand and gravel cased.

Typical wells and springs in Snyder County—Continued

No. on pl. 2	Location	Owner or name	Topographic situation	Altitude (feet) ^a	Type of supply ^b	Depth (feet)	Diameter (inches)	Principal water-bearing bed		Length of casing (feet)	Depth to water level (feet)	Method of lift ^c	Yield (gallons a minute)	Use of water ^c	Remarks
								Character of material	Geologic horizon						
382	Port Trevorton.....	W. F. Gross Silk Mill	Valley	420	Dr	102	6	Brown sandy shale	Portage.....	30	38±	P	3	D, I	Reported draw-down 80 feet at 4½ gallons a minute. Temperature 57°F. See analysis.
383	do.	do.	do.	420	Dr	116	6	Brown sand- stone	do.	30	36±	P	4.5	I	
	Chapman Township														
384	Chapman.....	Mr. Edwards.....	do.	420	Dr	48	6	Blue shale....	do.	25	6±	P	4	D	Reported pumped dry in 5 minutes at ½ gallon a minute.
385	Mokces Half Falls...	John B. Rohrer.....	do.	410	Dr	60	6	Shale?	Marcellus.....	40	?	H	3±	D	
386	Meiserville.....	Mr. Minium.....	do.	480	Dr	33	6	Hard blue sandstone	Hamilton.....	15	15±	H	¼±	D	
387	do.	Oscar Star.....	do.	490	Dr	43	6	do.	do.	17	5±	H	6-7	D	
388	Mahantango.....	Smith and Fisher...	do.	420	Dr	54	6	Blue shale....	Helderberg? .	20	10±	P	10	D	

^a Altitudes taken from nearest contour on topographic maps. No topographic maps for northwestern part of county.

^b Dr, drilled well; Du, dug well; DD, dug and drilled well; Sp, spring.

^c C, centrifugal pump; F, natural flow; H, lift pump, hand-operated; N, none; P, force pump, power operated; S, suction pump, power-operated; T, turbine pump.
^d C, condensing or cooling; D, domestic; I, industrial; N, none; P, public supply; S, stock.

Analyses of ground waters from Snyder County

Analyzed by E. W. Lohr. Parts per million. Numbers at heads of columns refer to corresponding numbers in the preceding table and on pl. 2.]

	333	345	358	374	383
Silica (SiO ₂).....			13		
Iron (Fe).....		16	.01		
Calcium (Ca).....	^a 16	^a 26	64	54	^a 28
Magnesium (Mg).....			11	3.2	
Sodium (Na).....	} ^b 4	^b 11	{ 16 3.9	} ^b c	^b 12
Potassium (K).....					
Bicarbonate (HCO ₃).....	62	82	183	161	103
Sulphate (SO ₄).....	^a 3	^a 20	30	^a 12	^a 7
Chloride (Cl).....	.2	14	27	1.2	24
Nitrate (NO ₃).....	.10	.10	22	1.4	15
Total dissolved solids.....	^b 56	^b 99	283	^b 156	^b 155
Total hardness as CaCO ₃	46	84	^b 205	^b 148	112
Date of collection (1934).....	Aug. 8	Aug. 7	Aug. 7	Aug. 11	Aug. 7

^a By turbidity.^b Calculated.^c Less than 5 parts.

SOMERSET COUNTY

Area 1,034 square miles. Population (1930) 80,764.

GEOGRAPHY

Somerset County, the third largest in the area covered by this report, ranks fourth in density of population, with about 78 inhabitants to the square mile, as against 215 for the entire State. Windber, Somerset, and Meyersdale had in 1930 respectively 9,205, 4,395, and 3,065 inhabitants, and six other boroughs had from 1,100 to 2,100. Coal mining is the leading industry, and in addition in 1929 there were 75 manufacturing establishments whose products were valued at \$5,000 or more annually. Even though large areas are devoted to mining or are forest-covered, 62 percent of the total land area is devoted to agriculture. The southern and central parts of the county are served by the main lines of the Western Maryland and the Baltimore & Ohio Railroads, and the northern part by branch lines of the Pennsylvania Railroad.

The topography in Somerset County is typical of the Allegheny Mountain section of the plateau province, except for the southeast corner, which lies in the Ridge and Valley province. The highest point in the county as well as in the State is the summit of Mount Davis, on Negro Mountain, which stands 3,213 feet above sea level. Several other places on the rather flat-topped Negro Mountain have altitudes of more than 3,000 feet. Allegheny Mountain, near the eastern border of the county, rises to an altitude of 2,949 feet in Allegheny Township, and Laurel Hill, which forms the western border of the county, stands at an altitude of 2,940 feet in Jefferson Township. Gladdens Run leaves the county in Southampton Township at an altitude of about 1,040 feet—the lowest point in the county. The maximum relief is therefore about 2,173 feet. Mount Davis stands about 1,600 feet above the Casselman River, which flows $4\frac{1}{2}$ miles to the northwest. Most of the county lies in the Ohio River drainage basin, the northern half being drained by tributaries of the Conemaugh River and most of the southern half by the Youghio-gheny River. Small areas in the southeastern part of the county are drained by the Raystown Branch of the Juniata River and by tributaries of the Potomac River.

GEOLOGY

The rock formations exposed in Somerset County range from the Chemung formation, of Upper Devonian age (oldest), to the Monongahela formation, of Pennsylvanian age (youngest) (pl.

1). The oldest rocks are exposed only along the Savage Mountain anticline in the southeastern part of the county, and the youngest rocks are exposed only in the Salisbury-Berlin and Johnstown synclines. The character and water-bearing properties of these formations are described in the first part of this report.

The Allegheny and Monongahela formations contain valuable coal beds, which are mined extensively. A view of one of these coal beds is shown in plate 16, B. The high ridges are formed by the Pocono and Pottsville formations.

The rocks have been gently folded into a succession of anticlines and synclines that trend northeast. The principal anticlines are, from west to east, the Laurel Hill anticline, Boswell Dome, the Negro Mountain anticline, and the Savage Mountain anticline. The principal synclines include, from west to east, the Johnstown, Somerset, Berlin, and Wellersburg synclines.

GROUND WATER

That part of the county lying in the Ridge and Valley province is largely mountainous but contains a few scattered farms and villages. Most of the water supplies in this section are obtained from dug wells or small springs and a few drilled wells.

West of the Allegheny Front drilled wells are numerous, although at many of the farms and villages dug wells and small springs are still used extensively. In this part of the county large yields are obtainable from drilled wells that tap any of the numerous sandstones in the Pottsville, Allegheny, or Conemaugh formations, and in some places from deeper wells that tap the sandstone in the Mauch Chunk shale. Most of the larger borings are situated along the several synclines, where water in one or more of these sandstones is under considerable head. All the sandstones crop out at considerably higher altitudes on Laurel Hill, Negro Mountain, and Allegheny Mountain, where the opportunity for recharge is excellent. The Pottsville and Mauch Chunk together form in some places a thick unit of sandstone, which in well 849 yields a total of 570 gallons a minute, the strongest well reported in the county. (See log.) Records are given below of about 25 other industrial or public-supply wells that yield from 50 to 400 gallons a minute. These sandstones grade into sandy shale or shale in some places, so that yields as large as those noted are not to be expected everywhere in the county. Moreover, some wells situated close to active coal mines, such as nos. 859 and 860, have been ruined.

The Pocono formation yields adequate supplies to a few wells near its outcrop, such as well 926, but in most of the county it is deeply-buried, and in the deeper synclines it may contain brackish or salty water. The Monongahela crops out only in small areas and is unimportant as a source of ground water.

Records are given below of seven wells in Somerset County that were reported to flow all or part of the year (wells 883, 885, 886, 900, 918, 919, and 925). Most of them flow only a small amount, but well 925 was reported to flow about 40 gallons a minute. The structural and stratigraphic conditions are favorable for flowing wells in the several extensive synclinal basins.

Weekly measurements are being made of the depth to water level in well 901. (See pp. 35-39.)

Nine analyses of ground water from wells in Somerset County are tabulated below, three each from the three principal water-bearers—the Pottsville, Allegheny, and Conemaugh. The quality of water to be expected from all the formations is summarized on pages 80-81. The three Pottsville waters were only slightly hard, as shown by analyses 854, 871, and 902, but one sample contained 27 parts per million of iron. Although present in excess amount in only 1 out of the 9 samples, iron is a very objectionable constituent of many of the ground waters in Somerset County, and trouble due to iron was reported in 6 wells in the Pottsville, 6 in the Allegheny, 4 in the Conemaugh, and 1 in the Mauch Chunk. One of the Allegheny waters was very soft; the other two were moderately hard, as shown by analyses 862, 878, and 884. Two of the Conemaugh waters were hard, and one was exceptionally hard, as shown by analyses 888, 899, and 924. The exceptionally hard water came from a well with a low yield located close to active coal mines. The ground waters of Somerset County are satisfactory for most purposes, although for some purposes some of the waters require treatment for the removal of iron and others may require softening.

PUBLIC SUPPLIES

At least 25 boroughs and villages in Somerset County have public water supplies, more than half of which use ground water or a combination of ground and surface waters. It was not possible in the time available in the field to obtain first-hand information concerning all the public supplies using ground water, and possibly some of the mining villages have been overlooked, but most of them, including all the larger ground-water supplies, are described below. Boroughs and villages that were reported to use

surface water exclusively include Acosta, Central City, Confluence, Gehagen, Hooversville, Jasa Hill, Jerome, Ralphton, Sipesville, Stony Creek Mine 2, and Windber. Well 855 formerly supplied Central City but was abandoned, owing to the high iron content of the water. Well 874 formerly supplied Sipesville, and well 873 formerly supplied Acosta, but these wells were abandoned in favor of a surface-water supply at Sipesville, which now supplies both villages. The large Quemahoning Reservoir, on Quemahoning Creek, supplies the Bethlehem Steel Corporation at Johnstown.

Berlin (population 1,393) is supplied by the Berlin Water Co. from eight springs that issue from sandstone on the outcrop of the Pottsville formation in the Allegheny Mountains about 3 miles east of the borough. Most of the springs discharge by gravity into a 600,000-gallon concrete reservoir, but one or two of the springs, which are used only in emergencies, are located on the opposite side of a ridge, and water from these springs is pumped over a saddle in the ridge to the reservoir. The water is distributed by gravity at pressures ranging from 80 to 100 pounds to the square inch. There are 27 fire hydrants in the system. The average daily consumption is about 40,000 gallons. The water from the springs ordinarily used requires no treatment, but that from the auxiliary springs is chlorinated.

Boswell (population 1,775) is supplied by the Jenners Water Co. When visited in August 1933 Boswell obtained its water from well 870, but it was planned to abandon the well in the fall of that year, owing to the iron content and hardness of the water, and to utilize surface water exclusively.

In 1929 Blough was reported to be supplied by the Wilbur Coal Mining Co. from wells and streams,⁹² but this supply was not visited by the writer. At that time a population of 400 was served, and the average daily consumption was 10,000 gallons.

Cairnbrook is supplied by the Loyalhanna Coal & Coke Co. from well 854, which is pumped at the rate of 300 gallons a minute. The raw water (see analysis 854) is treated with hydrated lime and filtered for softening and iron removal and is pumped to two steel tanks having a combined capacity of 40,000 gallons. The water is distributed by gravity at an average pressure of about 40 pounds to the square inch. There are 12 fire hydrants. In 1929 the average daily consumption was 80,000 gallons. From 25 to 50 percent of the water pumped is used by the Pennsylvania Railroad, and the remainder by the inhabitants.

⁹² Pennsylvania Dept. Health Yearbook 1929, p. 82, Harrisburg, 1930.

In 1929 Foustwell Village was reported to be supplied from wells by the Cosgrove-Meehan Coal Co.,⁹³ but this source was not visited by the writer. About 280 people were served and the average daily consumption was 10,000 gallons. The water was treated.

Friedens has four separate public water supplies, each furnishing a different group of families.

Sixty families in the northeastern part of Friedens are supplied by the Vulcan Smithing Coal Co. from well 877. The well pump lifts the water to a 5,000-gallon covered concrete reservoir on a hill near the well, whence the water is distributed by gravity. The water is aerated to remove hydrogen sulphide, but is not treated in any other way.

Twenty-two families and a creamery in the southeastern part of Friedens are supplied by the Friedens Mutual Water Co. from spring 879. Water from the enclosed spring flows by gravity into a 45,000-gallon covered concrete reservoir and is distributed by gravity. The water does not require treatment.

Twenty families in the southwestern part of Friedens (west of State highway 53) are supplied by the Friedens Water Co. from well 881. The well pump lifts the water into a 5,100-gallon covered concrete reservoir beside the well on a hilltop, and the water is distributed by gravity. There is one fire hydrant in the system. The water requires no treatment.

Twenty-four families in the southwestern part of Friedens are supplied by H. T. Bender from spring 880. The water is stored in a 10,000-gallon covered concrete reservoir near the spring and is distributed by gravity without treatment.

Garrett (population 878) is supplied by the Garrett Water Co. mainly from Bigby Creek and Piney Run. In times of drought or dry weather an auxiliary supply is furnished by well 920. The water is stored by means of two dams, the one on Bigby Creek impounding about 15,000,000 gallons, and that on Piney Run 200,000 gallons. The water is distributed by gravity at an average pressure of about 80 pounds to the square inch. There are 12 fire hydrants in the system. The average daily consumption is 260,000 gallons, of which 200,000 gallons is used by a railroad and 60,000 gallons by the inhabitants. The water from all sources is chlorinated. It was reported that from July to December 1930 both streams were essentially dry and the well

⁹³ *Idem*, p. 71.

was called upon to furnish the entire supply. During this period, however, no water was furnished to the railroad.

Twenty families in the western part of Hollsopple are supplied by R. Philip from five small springs (no. 847). The supply was reported to be very low in the summer of 1933.

In 1929 about 125 people in the Pretoria Mine Village in Hollsopple were reported to be supplied by the Pennsylvania Collieries, from a well, about 10,000 gallons a day being used,⁹⁴ but this supply was not visited by the writer.

Jenners is supplied by the Consolidation Coal Co. from well 871, which is pumped by air lift at the rate of 230 gallons a minute. A separate booster pump forces the water to three storage tanks having an aggregate capacity of 112,000 gallons, whence it is distributed by gravity at pressures ranging from 30 to 56 pounds to the square inch. The average daily consumption is 175,000 gallons, of which 90 percent is used at the company's powerhouse and 10 percent is used by the inhabitants. The water is of good quality, as shown by analysis 871.

Meyersdale (population 3,065) is supplied by the Sand Spring Water Company from Stams Run and several springs that issue from the hills east of the borough, and from a flowing well (no. 925) which discharges into one of the reservoirs. There are three other drilled wells (no. 926) two of which are sometimes pumped to supplement the supply when the springs and stream are low. When Meyersdale was visited in August, 1933, one spring had been dry since June 15. The wells range from 8 to 14 inches in diameter and from 150 to 1,000 feet deep. Well 923, formerly used as an auxiliary supply, has been abandoned. The company has one concrete reservoir and four dams impounding an aggregate of 10-12,000,000 gallons, from which water is distributed by gravity at pressures of 40 to 135 pounds to the square inch. In 1936 the average daily consumption through 830 meters was about 90,000 gallons. This does not include water used through fire hydrants (36 in the system) for fires, showers, street cleaning, etc. The water from all sources is chlorinated.

Rockwood (population 1,176) is supplied by the Rockwood Water Co. from several small streams and three auxiliary drilled wells (no. 900) all on the slope of Negro Mountain about 3 miles south of the borough. Two of the wells are used at times during the summer, and owing to their large yield the third well is never

⁹⁴ Idem, p. 71.

needed. The three reservoirs have an aggregate capacity of 3,000,000 gallons, and the water is distributed by gravity at pressures ranging from 100 to 110 pounds to the square inch. There are 30 fire hydrants. The average daily consumption by the inhabitants and one brewery is 100,000 gallons. (See also well 902.) The water from all sources is chlorinated. A separate system known as the Commercial Water Co. but also owned by the borough supplies the Baltimore & Ohio Railroad. The water is obtained from the same sources but is stored in a separate 1,500,000-gallon reservoir. The railroad uses about 83,000 gallons a day.

Somerset (population 4,395) is supplied by the Somerset Waterworks from four drilled wells (no. 887) just north of the borough. There are also three auxiliary drilled wells that are seldom needed and one well (no. 889) that has been abandoned owing to its small yield. The two drilled wells of the H. W. Walker Co. (no. 888) are close to the public wells, but the water supply was reported to be adequate even during the drought of 1930. The wells discharge into a 500,000-gallon concrete reservoir at the pumping plant, from which the water is pumped by one of two centrifugal pumps at the rate of 1,000 gallons a minute to two 500,000-gallon concrete distributing reservoirs on a hill above the borough. The water is distributed by gravity at pressures ranging from 65 to 100 pounds to the square inch. There are 130 fire hydrants. The average daily consumption is 450,000 gallons, all used for domestic purposes. The water is chlorinated and is similar in quality to that from well 888, for which an analysis is given below.

The Somerset County Home and Hospital, 2.7 miles east of Somerset, is supplied by spring 884 and two auxiliary drilled wells (nos. 882 and 883). An analysis of the water from the spring is given below.

Stoyestown (population 447) is supplied by the Stoyestown Water Co. from two drilled wells. The principal supply is obtained from well 862, across a hill 0.7 mile northwest of the borough. The well is pumped at the rate of 50 gallons a minute for 8 or 9 hours daily, and the water is discharged into a 90,000-gallon concrete sump, from which it is pumped a vertical distance of about 240 feet to the distributing reservoir by a three-stage force pump at the rate of 70 gallons a minute. The 100,000-gallon covered concrete distributing reservoir is located in a saddle at the west end of the borough, and the water is distributed by gravity at pressures ranging from 30 to 115 pounds to the square

inch. Well 861, which is equipped with a windmill, is alongside of the distributing reservoir and discharges about 10 gallons a minute into the reservoir when the wind is blowing. There are five fire hydrants. The average daily consumption is about 25,000 gallons. The water is chlorinated and is of good quality, as shown by analysis 862.

Typical wells and springs in Somerset County

No. on pl. 2	Location	Owner or name	Topographic situation	Altitude (feet) ^a	Type of supply ^b	Depth (feet)	Diameter (inches)	Principal water-bearing bed				Length of casing (feet)	Depth to water level (feet)	Method of lift ^d	Yield (gallons a minute)	Use of water ^e	Remarks
								Depth to top of bed (feet) ^c	Thickness (feet)	Character of material	Geologic horizon						
Conemaugh Twp.																	
845	Thomas Mill.....	John Croyl.....	Canyon	1,430	Dr	35	6	NB	(?)	(?)	Freepot sand- stone±	20	4	S	3-5	D	Water reported to be hard and to contain excess iron.
846	Davidsville.....	V. F. Weaver.....	Hillside	1,730	Dr	81±	6	54	(?)	Sandstone or shale	Brush Creek coal± do.	20	18±	P	5-7	D	Water reported to contain excess iron.
847	0.3 mile west of Hollsopple	R. Philip.....	do.	1,750±	5 Sp	.....	.....	.....	.....	Soft shale and sand- stone	do.	.....	.....	F	(?)	P	Normally supplies 20 houses. Springs very low in summer, 1933.
848	Paint Township Windber.....	John Lockre.....	do.	1,800	Dr	80	6	53	27	Shale.....	Below Upper Kittanning	55	30±	H	5±	D	Water reported to contain excess iron, 3 feet of coal reported at depth of 50 feet.
849	0.2 mile south of Windber	Berwind-White Coal Co.	Valley	*1,725.3	Dr	341	12-8	77 196	43 32	Hard sandstone White sandstone	Connoques- sing Mauch Chunk	86	28	T?	570	I	Driller encountered first large yield at depth of 115 feet (340 gallons a minute) second at 227 feet (230 gallons a min- ute). Water contains ex- cess iron and requires treatment. Emergency power-house supply. See log.
850	Hillsboro.....	William Hollsopple	do.	1,780	Dr	39	6	34	5	Crevice sandstone	Pottsville?.....	20	10±	H	5±	D	Water reported to contain excess iron. Reported small draw-down on bailing 35 gallons a minute.
851	Ogile Township 0.8 mile northwest of Ogletown	Anton Desort.....	Canyon	2,400	Dr	112	6	107	5	Sandstone..	Pottsville or Mauch Chunk	80	58±	P	5+	D	Water reported to be of good quality. Reported small draw-down on bailing 35 gallons a minute.

^a Altitude from Berwind-White Coal Co.

Shade Township	Ira Mangus.....	Hillside	2, 170	Dr	80	6	70	10	Shale.....	Mahoning sandstone Kittanning sandstone	22 20±	40± 30±	P H	5 5	D D	Reported bailed at 35 gallons a minute. Reported small draw-down on bailing 30 gallons a minute. Water reported to contain excess iron. Well enters Mauch Chunk, but most water is in Pottsville. Reported draw-down 2 or 3 feet. Tested at 400 gallons a minute for 72 hours when drilled with small draw-down. Water contains hydrogen sulphide and excess iron. Temperature 50° F. See analysis. Driller reported very little water in Pottsville. Reported draw-down 65 feet after 2 weeks' pumping. Well formerly used for public supply but abandoned because of excess iron in water. Some water in Lower Kittanning coal at 21 feet.
S52	1.1 miles northeast of Hooversville	Hillside	2, 170	Dr	80	6	70	10	Shale.....	Mahoning sandstone	22	40±	P	5	D	Reported bailed at 35 gallons a minute. Reported small draw-down on bailing 30 gallons a minute. Water reported to contain excess iron. Well enters Mauch Chunk, but most water is in Pottsville. Reported draw-down 2 or 3 feet. Tested at 400 gallons a minute for 72 hours when drilled with small draw-down. Water contains hydrogen sulphide and excess iron. Temperature 50° F. See analysis. Driller reported very little water in Pottsville. Reported draw-down 65 feet after 2 weeks' pumping. Well formerly used for public supply but abandoned because of excess iron in water. Some water in Lower Kittanning coal at 21 feet.
S53	Hooversville.....	do.	1, 750	Dr	70	6	60	10	Sandstone..	Kittanning sandstone	20±	30±	H	5	D	Reported small draw-down on bailing 30 gallons a minute. Water reported to contain excess iron. Well enters Mauch Chunk, but most water is in Pottsville. Reported draw-down 2 or 3 feet. Tested at 400 gallons a minute for 72 hours when drilled with small draw-down. Water contains hydrogen sulphide and excess iron. Temperature 50° F. See analysis. Driller reported very little water in Pottsville. Reported draw-down 65 feet after 2 weeks' pumping. Well formerly used for public supply but abandoned because of excess iron in water. Some water in Lower Kittanning coal at 21 feet.
S54	Cairnbrook.....	Slope	2, 150	Dr	430	8	130+	100-	do.	Pottsville.....	130	30	T	300	P	Reported small draw-down on bailing 30 gallons a minute. Water reported to contain excess iron. Well enters Mauch Chunk, but most water is in Pottsville. Reported draw-down 2 or 3 feet. Tested at 400 gallons a minute for 72 hours when drilled with small draw-down. Water contains hydrogen sulphide and excess iron. Temperature 50° F. See analysis. Driller reported very little water in Pottsville. Reported draw-down 65 feet after 2 weeks' pumping. Well formerly used for public supply but abandoned because of excess iron in water. Some water in Lower Kittanning coal at 21 feet.
S55	0.7 mile southeast of Central City	Canyon	2, 230	Dr	365	8	205	160	Sandstone and red shale	Mauch Chunk	30	10±	(?)	400	N	Reported small draw-down on bailing 30 gallons a minute. Water reported to contain excess iron. Well enters Mauch Chunk, but most water is in Pottsville. Reported draw-down 2 or 3 feet. Tested at 400 gallons a minute for 72 hours when drilled with small draw-down. Water contains hydrogen sulphide and excess iron. Temperature 50° F. See analysis. Driller reported very little water in Pottsville. Reported draw-down 65 feet after 2 weeks' pumping. Well formerly used for public supply but abandoned because of excess iron in water. Some water in Lower Kittanning coal at 21 feet.
S56	2.1 miles southeast of Reels Corners	Upland	2, 820	Dr	97	6	96	1	Crevice in sandstone	Lower Allegheny or Pottsville	46	20±	H?	7	D	Reported small draw-down on bailing 30 gallons a minute. Water reported to contain excess iron. Well enters Mauch Chunk, but most water is in Pottsville. Reported draw-down 2 or 3 feet. Tested at 400 gallons a minute for 72 hours when drilled with small draw-down. Water contains hydrogen sulphide and excess iron. Temperature 50° F. See analysis. Driller reported very little water in Pottsville. Reported draw-down 65 feet after 2 weeks' pumping. Well formerly used for public supply but abandoned because of excess iron in water. Some water in Lower Kittanning coal at 21 feet.
S57	1.4 miles southeast of Reels Corners	Hillside	2, 770	Dr	200	6	190	10	Shale.....	Middle Kittanning±	70	100±	P	5-5	D	Reported small draw-down on bailing 30 gallons a minute. Water reported to contain excess iron. Well enters Mauch Chunk, but most water is in Pottsville. Reported draw-down 2 or 3 feet. Tested at 400 gallons a minute for 72 hours when drilled with small draw-down. Water contains hydrogen sulphide and excess iron. Temperature 50° F. See analysis. Driller reported very little water in Pottsville. Reported draw-down 65 feet after 2 weeks' pumping. Well formerly used for public supply but abandoned because of excess iron in water. Some water in Lower Kittanning coal at 21 feet.
S58	Bucktown.....	do.	2, 440	Dr	100	6	80	20	do.	Mahoning sandstone	14	50±	P	7+	D,S	Reported small draw-down on bailing 30 gallons a minute. Water reported to contain excess iron. Well enters Mauch Chunk, but most water is in Pottsville. Reported draw-down 2 or 3 feet. Tested at 400 gallons a minute for 72 hours when drilled with small draw-down. Water contains hydrogen sulphide and excess iron. Temperature 50° F. See analysis. Driller reported very little water in Pottsville. Reported draw-down 65 feet after 2 weeks' pumping. Well formerly used for public supply but abandoned because of excess iron in water. Some water in Lower Kittanning coal at 21 feet.
S59	Quemahoning Twp. 1.1 miles southeast of Kantner (Stoyestown station)	do.	2, 240	Dr	172	6	67	5	do.	Lower Freeport±	24	30±	(?)	(?)	N	Good well when drilled in 1928; water level lowered and yield greatly reduced by undermining. Dry hole. Water presumably drained by coal mines.
S60	0.9 mile southeast of Kantner	do.	2, 160±	Dr	212	6	.....	.....	Shale and sandstone	Allegheny.....	(?)	.....	N	0	N	Good well when drilled in 1928; water level lowered and yield greatly reduced by undermining. Dry hole. Water presumably drained by coal mines.
S61	Stoyestown.....	Ridge	2, 140	Dr	60 or 80	8	NB	(?)	(?)	Bakerstown coal±	30	?	W	10	P	Good well when drilled in 1928; water level lowered and yield greatly reduced by undermining. Dry hole. Water presumably drained by coal mines.

Typical wells and springs in Somerset County—Continued

No. on plat. 2	Location	Owner or name	Topographic situation	Altitude (feet) ^a	Type of supply ^b	Depth (feet)	Diameter (inches)	Principal water-bearing bed				Length of casing (feet)	Depth to water level (feet)	Method of lift ^d	Yield (gallons a minute)	Use of water ^e	Remarks
								Depth to top of bed (feet) ^c	Thickness (feet)	Character of material	Geologic horizon						
862	0.7 mile northwest of Stoyestown	Stoyestown Water Co.	Canyon	1,900	Dr	267	10	NB	(?)	(?)	Johnstown limestone [±]	40	100	P	50	P	Draw-down 50 feet. Tem- perature 51°F. See analysis. Water chlori- nated. Wells in and near Stoyestown reported to yield but little water, presumably owing to mining activities.
863	0.4 mile south of Ralphitou Jenners Township	Quemahoning Coal Co. (Rhodes farm)	Upland	2,040	Dr	74	6	NB	(?)	Shale.	Mahoning sandstone	20	30 [±]	H	2-3	D	
864	Glessner.	? (store).	Hillside	1,880	Dr	60	6	NB	(?)	do.	Below Upper Pittsburgh limestone	20	?	H	8-10	D	
865	1.1 miles north of Pitttown	Guy Griffith.	do.	1,920	Dr	337	6	NB	(?)	Black shale.	Kittanning sandstone	240	280 [±]	H?	2 [±]	D	
866	1.3 miles northwest of Jennertown	Dr. Willer.	do.	1,980	Dr	154	6	NB	(?)	Shale.	Below Johns- town ls.	(?)	135 [±]	H?	2.5	D	
867	Jennertown.	White Star Hotel	Ridge	1,950	Dr	150	6	145	5	Dark shale.	Morgantown [±] sandstone	18 [±]	100 [±]	P	36	D	Reported small draw- down.
868	do.	H. L. Emert.	do.	1,950	Dr	117	6	NB	(?)	(?)	Above Mor- gantown ss.	18	57 [±]	P	3	D	Water reported good.
869	Jenners Crossroads	State Highway Garage	Hillside	1,940	Dr	245	4	210	35	Shale.	Johnstown limestone [±]	210	210 [±]	H or P	3	D	
870	Boswell.	Jenners Water Co.	Upland	2,000	Dr	328	5	NB	(?)	Sandstone.	Pottsville.	(?)	170 [±]	A	35-50	P	On Boswell dome. Water reported to be hard and to contain excess iron. Was to be supplanted by stream supply in fall of 1933.
871	Jenners.	Consolidation Coal Co.	Valley	1,825	Dr	278	10	NB	(?)	Sandstone?	do.	173	40	A	230	P, I	Public and power-house supply. Temperature 52°F. See analysis.

872	0.8 miles southwest of Ralplhton	American Natural Gas Co. (Moore well)	Hillside	2,060	Dr	4,095	(?)	158	4	Slale.	Lower Allegheny Pottsville. Pocono.	846	?	N	?	N	Abandoned gas well. Small yield of water at 158 feet, large yield at 282 feet. Water at 742 feet probably salty. No water below 846 feet.
873	Acosta.	Consolidation Coal Co.	Valley	1,840	Dr	169	10	NB	(?)	do.	Pottsville.	(?)	?	N	200	N	Formerly used for public supply. Acosta now buys water from Spiesville.
874	Lincoln Township																
874	Spiesville.	Spiesville Water Co.	Hillside	2,040	Dr	79	8	NB	(?)	Slale and sandstone	Brush Creek coal±	21.5	25±	N	10	N	Formerly used for public supply. Surface water now used.
875	Jefferson Township																
875	0.4 mile south of Bakersville	Pete Brugh.	Valley	1,980	Dr	40	6	15	40	Hard white sandstone	Mahoning sandstone	(?)	12±	H	5±	D	Water reported to be hard and to contain hydrogen sulphide. No water above D coal, drained by mines.
876	1.2 miles east of Bakersville	J. Pile.	Hillside	2,080	Dr	68	6	NB	(?)	Sandstone. .	Buffalo sandstone	30	20±	H	3	D	Temperature 52°F. See analysis.
877	Somerset Township																Reported never dry.
877	0.3 mile east of Friedens	Vulean-Smithing Coal Co.	Valley	2,030	Dr	130	8	NB	(?)	Sandstone?	Above Lower Kittanning coal	20	30±	P	15	P	Reported never dry.
878	Friedens.	IXL Creamery.	do.	2,020	Dr	158	8	NB	(?)	do.	Kittanning sandstone±	20	40±	P	60±	C,I	Temperature 52°F. See analysis.
879	0.7 mile southeast of Friedens	Friedens Mutual Water Co.	Hillside	2,100	Sp					(?)	Upper Kittanning coal±			F	50±	P,I	Temperature 52°F. Reported never dry.
880	Friedens.	H. T. Bender.	do.	2,100	Sp					Sandstone and slale ?	Mahoning sandstone±			F	10±	P	Reported never dry.
881	do.	Friedens Water Co.	Hilltop	2,140	Dr	120±	6	NB	(?)	Sandstone. .	do.	(?)	50±	P	10	P	Reported draw-down 43 feet. Water hard and contains excess iron.
882	2.7 miles east of Somerset	Somerset County Home	Hillside	2,400	Dr	172	10	NB	(?)	Sandstone. .	Above Lower Kittanning coal	100	90	T	125	P	Reported draw-down 50 feet. Well flowed from 1922 to 1929, not since.
883	do.	do.	do.	2,400	Dr	52	14	37	15	Slale.	Lower Freeport	20	0	P	35	P	Small yield in summer, large in winter. Temperature 52°F. See analysis.
884	do.	do.	do.	2,400	Sp					Hard slale.	Upper Freeport±			F	5 or 10 to 175	P	Water flows out overflow at depth of 4 feet but would flow at surface.
885	1.9 miles north of Somerset	Bob Gilmore.	do.	2,200±	Dr	52	6	NB	(?)	Slale or sandstone	Ames limestone±	26	4	S	5±	D	Water reported good.
886	1.2 miles north of Somerset	Russel Deaner.	do.	2,180	Dr	55	6	55	(?)	Sandstone. .	Saltsburg sandstone±	26	+ to 8	S	15±	D	Flows in winter until about July. Water reported good.

Typical wells and springs in Somerset County—Continued

No. on pl. 2	Location	Owner or name	Topographic situation	Altitude (feet) ^a	Type of supply ^b	Depth (feet)	Diameter (inches)	Principal water-bearing bed				Length of casing (feet)	Depth to water level (feet)	Method of lift ^d	Yield (gallons a minute)	Use of water ^e	Remarks
								Depth to top of bed (feet) ^c	Thickness (feet)	Character of material	Geological horizon						
887	0.3 mile north of Somerset	Somerset Water-works	Valley	2,100	7 Dr	116-172	8, 10	116	(?)	Sandstone..	Mahoning sandstone	50	21	C,P	150	P	7 drilled wells; 4 used. Depths 116, 144, 135, 122, 120, 122, 172 feet. One 8-inch; rest 10-inch. 3 centrifugal and one force pump in pits 30 feet deep. Yield 150 gallons a minute each. See log. See analysis for well 888 in same stratum. Water softer to be installed.
888	do.	H. W. Walker Co.	do.	2,100	2 Dr	120	8	NB	(?)	do.	do.	(?)	20±	C,P	150-175	C,I	Pumps in 30-foot pits. Water makes clear ice. Temperature 51°F. See analysis.
889	Somerset.....	Somerset Water-works	Hillside	2,140	Dr	700	(?)	(?)	(?)	(?)	Pottsville.....	(?)	(?)	N	?	N	Abandoned because of small yield.
890	2.8 miles southwest of Somerset	Mr. Marshall.....	Ridge	2,180	Dr	107	6	90.5	16.5	Shale.....	Lower Conemaugh	21	30±	H	5±	D	Reported draw-down 20 feet at 15 gallons a minute. Some water at 50 feet.
891	Stony Creek Twp. 2.0 miles northwest of Bucktown	Foster Schaffer.....	do.	2,340	Dr	85	6	75	10	Hard shale	Kittanning sandstone±	17	25±	P	5	D,S	Reported tested at 30 gallons a minute. Water reported to contain excess iron.
892	Reels Corners.....	Albert Lyons.....	Hillside	2,530	Dr	79	6	75	(?)	Crevice in sandstone	Mahoning sandstone±	20	15±	S	5	D	Reported draw-down 1 or 2 feet at about 35 gallons a minute. Water reported to contain excess iron.
893	Shanksville.....	Consolidated School	do.	2,240	Dr	97	8	78	19	Dark shale.	Below Bakers-town coal	48	12±	P?	5±	D	
894	Brotherton.....	Albert Wright.....	Slope	2,340	Dr	65	6	NB	(?)	Sandstone..	Conemaugh...	21	15	H	5	D	

895	Allegheny Township	Will Hickey.....	Valley	1,420	Dr	35±	6	NB	(?)	Sandstone or shale	Chemung.....	(?)	?	H	3-5	D	Location not checked. Do. Temperature 53°F. See analysis. Uses boiler compound. Uses mine drainage for cooling. Yield only 8.5 gallons a minute each.
896	New Baltimore.....	James Tipton.....	Hillside	2,040	Dr	207	6	201	6	Red shale...	do.	23	60±	H	5±	D	
897	Mount Zion.....																
898	Brothers Valley Township	W. Flickinger.....	do.	2,320	Dr	111	6	NB	(?)	Shale or sandstone	Allegheny or Pottsville	17	?	H	3-5	D	
899	0.2 mile south of Macdonaldton	John Sarver.....	Ridge	2,330	Dr	68	6	NB	(?)	(?)	Conemaugh...	19.5	?	H	3-5	D	3 wells, same depths, same yield, 250 gallons a minute each, reported draw-down less than 1 foot. Only 2 wells used. Unconfirmed report that large opening was encountered at 100 feet. Water reported soft, but to contain some iron. U. S. Geological Survey observation well; see pp. 35-39.
	0.2 mile south of Berlin	Meadow Gold Dairies, Inc.	Canyon	2,150	2 Dr	75±	8	NB	(?)	Sandstone and shale	do.	18	10 to 20	P	8.5	I	
900	Black Township																
	3.0 miles south of Rockwood	Rockwood Water Co.	Upland	2,320±	3 Dr	150	10	100	(?)	Opening?...	Pottsville, or Mau. Chunk	30	+ to 29	S, A	250	P	
901	Markleton.....	N. B. Sanner.....	Side of Valley	1,700	Du	19	24±	NB	(?)	Soil or rock.	Middle Kittanning coal±	19	10 to 17	N	?	N	
902	Milford Township																Reported small draw-down. Water contains some hydrogen sulphide. Water used for all purposes including beer. Temperature 52°F. See analysis.
	0.2 mile west of Rockwood	Rockwood Brewery Co.	do.	1,820	Dr	150	8	NB	(?)	Sandstone?	Pottsville.....	(?)	40±	P	150	C, I	
903	Centerville.....	Elwood Mosholder	Hilltop	2,120	Dr	107	6	85	22	Shale.....	Conemaugh...	27	12±	H or W	5±	D	
904	Upper Turkeyfoot Township																
	Kingwood.....	E. B. Lear.....	Ridge	2,260	Dr	90	6	70	20	Shale.....	Conemaugh...	40	20±	H	5±	D	

Typical wells and springs in Somerset County—Continued

No. on pl. 2	Location	Owner or name	Topographic situation	Altitude (feet) ^a	Type of supply ^b	Depth (feet)	Diameter (inches)	Principal water-bearing bed				Length of casing (feet)	Depth to water level (feet)	Method of lift ^d	Yield (gallons a minute)	Use of water ^e	Remarks
								Depth to top of bed (feet) ^c	Thickness (feet)	Character of material	Geologic horizon						
905	Upper Turkeyfoot Township	Mrs. C. E. Yeagley Confluence Ice Co.†	Valley do.	1,320	Dr	280	6	NB	(?)	(?)	Allegheny....	(?)	15±	S	5+	N	Uses city water.
906	do.			1,320	Dr	200±	6	NB	(?)	(?)	do.	125	40±	(?)	120±	N	Out of business.
907	Addison Township	† (?)	Slope	1,400	Dr	70±	6	NB	(?)	Sandstone..	Upper Alle- gheny	(?)	12±	I	1-3	D	
908	do.	Mrs. W. A. Fry (?)	do. Valley	1,380	Dr	92	6	NB	(?)	(?)	do.	20±	15±	N	?	N	
909	Listonburg.....			1,740	Dr	21	6	NB	(?)	Crevice in sandstone	do.	(?)	16±	H	1-3	D	
910	Addison.....	F. L. Jeffries.....	Hillside	2,010	Dr	65	6	50	15	Hard sand- stone	Connellsville sandstone	9	30±	P	7	D	Water contains excess iron and is filtered.
911	do.	Alex Hart.....	Ridge	2,100	Dr	50	6	45	(?)	Coal.....	Little Pitts- burgh coal	45	?	P	4	D	Water reported potable.
912	Elklick Township	Dr. Springer.....	Valley	2,700	Dr	78+	5	50	(?)	Soft sand- stone	Mauch Chunk	48	.....	(?)	(?)	D	Well unfinished. Some water at 50 feet.
913	0.8 mile north of Mount Davis	Pennsylvania Dept. of Forests and Waters	Hilltop	3,213	Dr	131	6	127	4	White sand- stone	Pottsville....	(?)	80±	H	6	D	Highest point in State.
914	1.7 miles northwest of Salisbury	Charles Sechler....	Hillside	2,300	DD	60	5	50	10	Blue shale	Upper Con- maugh	13	25±	H	3	D	
915	1.0 mile east of Boynton	Pine Grove Swim- ming Pool	Valley	2,020	Dr	80±	8	NB	(?)	Sandy shale	Mahoning	20	15±	T	76	D,I	Reported small draw- down.
916	Salisbury.....	A. E. Livingston...	Slope	2,090	Dr	118	5	65.5	25.5	Soft sand- stone	Above Ames limestone	58	50±	P	5±	D	Do.
917	do.	Clay Newman.....	Hillside	2,130	Dr	62	5	56	6	Sandy shale	Ames lime- stone±	23	40±	P	5±	D	
918	Niverton.....	L. S. Yoder.....	Valley	2,220	Dr	34.5	5	29	5.5	Black shale..	Connellsville sandstone±	26	+9±	F	5±	D	
919	0.7 mile south of Springs	Amos J. Yoder...	Hillside	2,450	Dr	38	5	33	5	Hard sand- stone	do.	28	+2±	F,I	5±	D	Flows a small amount.

Summit Township	Garret Water Co...	do.	2,220	Dr	206	10	NB	(?)	Sandstone?	Consequences- sing ss. Below Lower Kittanning coal	10	0	A	100±	P	Auxiliary supply. Reported small draw-down. Water drained above coal. Air entered well from mine workings and well abandoned.
920 0.8 mile northwest of Garret	Garret Water Co...	do.	2,220	Dr	206	10	NB	(?)	Sandstone?	Consequences- sing ss. Below Lower Kittanning coal	10	0	A	100±	P	Auxiliary supply. Reported small draw-down. Water drained above coal. Air entered well from mine workings and well abandoned.
921 0.5 mile northeast of Garret	Charles H. Fogel...	Slope	1,970±	Dr	169	5	168	1.5	Limestone.	Below Lower Kittanning coal	0	166±	N	?	N	Water drained above coal. Air entered well from mine workings and well abandoned.
922 0.9 mile northwest of Meyersdale	Richard Franklin	Valley	1,940	Dr	58	5	50	8	Sandy shale	Saltsburg sandstone±	31	20±	H	5±	D	Reported some draw-down on bailing 10 gallons a minute.
923 0.9 mile north of Meyersdale	Sand Spring Water Co.	Hillside	1,980±	Dr	376	14	(?)	(?)	(?)	Mahoning sandstone	(?)	?	P	?	N	Formerly used for public supply. Yield not known.
924 Meyersdale.....	Meyersdale Dairy Co.	Valley	1,950	Dr	125	8	NB	(?)	Sandy shale	Morgantown sandstone	30	10±	T	90	C,I	Reported draw-down 50 feet. Temperature 54°F. See analysis.
925 1.0 mile southeast of Meyersdale	Sand Spring Water Co.	Hillside	2,320±	Dr	300	6	NB	(?)	Sandstone?	Pottsville....	(?)	+ (?)	F	40±	P	Water reported to contain hydrogen sulphide and excess iron.
926 0.8 mile south of Keystone	do.	Valley	2,320±	Dr	800- 1,000	8?	NB	(?)	do.	Pocono....	(?)	(?)	A	25±	P	3 auxiliary wells; 2 used. Yield about 25 gallons a minute each.
Southampton Twp.																
927 Wellersburg.....	Mrs. H. L. Cassen.	Hillside	1,320	Dr	65	6	NB	(?)	Sandstone..	Conemaugh...	20	10±	P	5±	D	Similar to other drilled wells in town.

^a Altitudes taken from nearest contour on topographic maps unless otherwise indicated.

^b Dr, drilled well; Du, dug well; DD, dug and drilled well; Sp, spring.

^c NB, near bottom.

^d A, air lift; C, centrifugal pump; F, natural flow; H, lift pump, hand-operated; I, pitcher pump, hand-operated; N, none; P, force pump, power-operated; S, suction pump, power-operated; T, turbine pump; W, windmill.

^e C, condensing or cooling; D, domestic; I, industrial; N, none; P, public supply; S, stock.

^f Well data from Piper, A. M., Ground water in southwestern Pennsylvania; Pennsylvania Geol. Survey, 4th ser., Bull. W 1, p. 298, 1933.

Partial analyses of ground waters from Somerset County

[Analyzed by E. W. Lohr. Parts per million. Numbers at heads of columns refer to corresponding numbers in the preceding table and on pl. 2.]

	854	862	871	878	884	888	899	902	924
Iron (Fe).....	27								
Calcium (Ca).....	a 40	a 35	a 19	73	a 2	a 65	144	a 20	65
Magnesium (Mg).....				16			36		
Sodium and potassium (Na+K) (calculated)....	7	18	5	b	c	5	4	56	22
Bicarbonate (HCO ₃).....	3.0	192	0	120	6.0	186	130	168	257
Sulphate (SO ₄).....	117	a 12	93	137	a 3	a 45	388	30	17
Chloride (Cl).....	c	1	6.0	1.0	2.0	13	4.0	28	30
Nitrate (NO ₃).....	.10	.60	.0	.0	5.0	.50	.90	.0	2.0
Total dissolved solids (calculated).....	168	179	140	286	19	240	641	225	289
Total hardness as CaCO ₃	111	132	94	d 248	14	207	d 508	87	225
Date of collection (1933).....	Oct. 12	Oct. 12	Oct. 12	Oct. 12	Oct. 12	Oct. 12	Oct. 12	Oct. 12	Oct. 12

By turbidity.

b Less than 5.

c Less than 1.

d Calculated.

Log of well of Berwind-White Coal Co., near Windber

[No. 849. Authority, R. Phaler, chief engineer.]

	Thick- ness (feet)	Depth (feet)		Thick- ness (feet)	Depth (feet)
Soil.....	10	10	Shale, blue.....	5	125
Slate.....	15	25	Sandstone, blue.....	5	130
Coal.....	1.5	26.5	Shale, blue.....	6	136
Sandstone, dark.....	13.5	40	Sandstone, blue.....	13.3	149.3
Sandstone, hard.....	5	45	Shale, blue.....	6.7	156
Coal.....	2	47	Shale, red ³	29	185
Sandstone, gray.....	10	57	Shale, green.....	11	196
Slate, bony.....	2	59	Sandstone, white ²	32	228
Rock, hard, black.....	1	60	Shale, dark red.....	8	236
Slate, soft, black.....	2	62	Sandstone, gray.....	8	244
Sandstone, hard, white.....	12	74	Shale, gray.....	6	250
Fire clay, coal streaks.....	3	77	Shale, red.....	15	265
Sandstone, hard, white.....	18	95	Sandstone, hard, light.....	30	295
Sandstone, hard, dark ¹	20	115	Shale, red.....	30	325
Sandstone, hard, blue.....	5	120	Shale, hard, blue.....	16	341

¹ Water-bearing at 115 feet.² Water-bearing at 227 feet.³ Top of Mauch Chunk.

UNION COUNTY

Area 305 square miles. Population (1930) 17,468.

GEOGRAPHY

Union County, the smallest county in the area, had in 1930 about 57 inhabitants to the square mile, as compared with 215 for the entire State. Lewisburg and Mifflinburg, which in 1930 had 3,308 and 1,959 inhabitants, respectively, are the only boroughs in the county having populations of 1,000 or more. Agriculture is the principal industry, but owing to the mountainous nature of the western part, only about 49 percent of the total land area is farmed. The Federal census of 1929 credits the county with 33 manufacturing establishments whose products were valued at \$5,000 or more annually. The county is served by the Reading Railroad, which parallels the Susquehanna River, and by a branch line of the Pennsylvania Railroad that runs westward from Lewisburg into Centre County.

The topography in Union County is fairly typical of the Ridge and Valley province. The western part is mountainous, and several of the ridges, such as South White Deer Ridge and Shamokin Mountain, extend eastward to the Susquehanna River. The highest point is not definitely known, as the southwestern part of the county has not been mapped topographically. In the area that has been mapped the highest point is Naked Mountain, in Hartley Township, which stands at an altitude of 2,100 feet. Nittany Mountain, in White Deer Township, rises to an altitude of 2,000 feet. The eastern part along the Susquehanna River is characterized by large fertile valleys. The Susquehanna River leaves the county at an altitude of about 420 feet, the lowest point in the county. The maximum known relief is therefore about 1,680 feet. Union County is drained entirely by the Susquehanna River, chiefly by the West Branch, which forms the eastern boundary, but in part by Penns Creek, a tributary of the main river.

GEOLOGY

The Paleozoic rocks exposed in Union County range from the Reedsville shale of Upper Ordovician age (oldest), to the Catskill formation, of Upper Devonian age (youngest). (See pl. 1.) The Reedsville shale is exposed in several intermontane valleys along the western border, and the Catskill formation is exposed only at the southeast corner, at the confluence of the North and West Branches of the Susquehanna. Much younger beds of sand and gravel of Pleistocene age are found along the West Branch of the Susquehanna and at some places in the interior of the county.

The character and water-bearing properties of these formations are described in the first part of this report.

The mountainous part of the county is formed by the Oswego, Juniata, Tuscarora, and Clinton formations. The fertile valleys are underlain mainly by the Cayuga group but in part by Lower and Middle Devonian rocks. The Upper Devonian rocks form a hilly area at the southeast corner.

Union County is crossed by numerous folds trending slightly north of east. Most of the anticlines that characterize the Seven Mountain region of Centre, Huntingdon, Mifflin, and Union Counties pitch downward and gradually die out in and east of Union County, thus causing most of these mountains to terminate within the county.

GROUND WATER

In Union County, as in Juniata County, the limestones and calcareous shales of the Cayuga group and the Helderberg limestone are the most extensively utilized water-bearers, as they underlie most of the inhabited part. More than 70 percent of the wells listed in the accompanying tables end in these formations. These formations are also probably the most productive water-bearers in the county and furnish 27 to 100 gallons a minute to several wells (nos. 272, 296, 297, and 311 to 314) and 200 to about 1,500 gallons a minute to several large limestone springs (nos. 271, 277 and 278).

The Juniata, Oswego, Tuscarora, and Clinton formations supply numerous mountain springs, such as nos. 267, 268, and 275, and the Clinton supplies a few hillside wells for sanitariums, such as nos. 259, 283, and 284. The probable maximum water-yielding capacity of the Clinton, which is largely shale, is indicated by the record of well 259. Although this well is 606 feet deep it yields only 42 gallons a minute with moderate draw-down, and at 60 to 80 gallons a minute the water level falls nearly to the bottom.

The Middle and Upper Devonian rocks underlie hilly farming areas and generally yield small but reliable supplies.

So far as is known, the Pleistocene and Recent deposits of sand and gravel along the Susquehanna are not utilized as sources of water. In well 319, at Turtleville, 27 feet of water-bearing sand and gravel was cased off, and in well 323, near Winfield, 41½ feet of similar material was cased off. Possibly moderately large supplies could be developed in some places from this material, by the use of well screens. (See pp. 57, 58.)

Dug wells still supply many of the farms in low-lying sections and supply most of the residents of some of the smaller settlements, such as Hartleton, Cowan, and Mazeppa.

Wells 272 and 283 were the only flowing wells observed in the county. Possibly others could be obtained, but there appear to be no areas where wells of this type could be expected with certainty.

Five analyses of ground waters from wells and springs and two analyses of surface water from streams in Union County are tabulated below, and the quality of water to be expected from the different formations is summarized on pages 80, 81. Analyses 275 and 283, of waters from the Clinton formation, indicate very soft water with very little dissolved mineral matter. Analyses 272, 311, and 314 from the Cayuga group and Helderberg limestone, the principal water-bearers in the county, indicate hard waters containing appreciable amounts of calcium and sulphate, which form hard boiler scale. Analyses 272 and 311 probably represent about the best water obtainable from these formations, as many of the Cayuga or Helderberg waters are much harder and much more concentrated than these two, as shown by the analysis of water from a well across the river in Northumberland County.⁹⁵ The water from this well contained 2,102 parts per million of dissolved solids and had a hardness of 1,447 parts. The Bloomsburg red shale, however, generally yields water of much better quality than any of the other formations of the Cayuga group.

None of the samples contained iron in sufficient quantity to produce a precipitate, nor was an excess of iron reported in any of the waters. In general, except for some of the very hard Cayuga or Helderberg waters, the ground waters of Union County are satisfactory for most ordinary purposes.

PUBLIC SUPPLIES

Lewisburg, Mifflinburg, and West Milton use surface water, Lewisburg and West Milton being supplied by the White Deer Mountain Water Co., which also supplies Milton, in Northumberland County. The Northeastern Federal penitentiary, near Lewisburg, is also supplied with surface water by the White Deer Mountain Water Co. (See analysis A.) Allenwood, Devitt Camp, and New Berlin are supplied with ground water, as described below. Laurelton State Village derives most of its water from small mountain streams but has an auxiliary drilled-well supply (well 259).

⁹⁵ Lohman, S. W. Ground water in northeastern Pennsylvania: Pennsylvania Geol. Survey, 4th ser., Bull. W 4, p. 204, 1937.

Eighteen families in Allenwood are supplied from well 286, owned by Frank Allen. The water is lifted by the well pump to a 4,050-gallon concrete reservoir, whence it is distributed by gravity. The average daily consumption is about 3,000 gallons. The water requires no treatment.

Devitt Camp, near Allenwood, is supplied from one small spring and two drilled wells (nos. 283, 284) owned by the institution, which is headed by Dr. William Devitt. The small spring issues from the Clinton formation and was observed to yield only about 2 gallons a minute on August 3, 1934. The wells, which furnish most of the supply, discharge into a concrete reservoir, and one of the wells flows a small amount. The reservoir, which holds nearly 13,000 gallons, is equipped with a float-operated switch that automatically starts and stops the electrically driven well pumps whenever the water level falls below or rises above certain points. The water is distributed by gravity, and about 160 people are supplied. The water requires no treatment and is of very good quality, as shown by analysis 283. Another drilled well (no. 282) supplies the barn at the farm.

New Berlin (population 459) is supplied by the New Berlin Borough Waterworks from seven small springs (no. 275) on Shamokin Mountain, north of the borough. The springs discharge by gravity into a 187,000-gallon covered concrete reservoir below the springs, whence the water is distributed by gravity at pressures ranging from 40 to 80 pounds to the square inch. There are 14 fire hydrants. All the inhabitants and one creamery are supplied, but no record is kept of the daily consumption. The water requires no treatment and is of very good quality, as shown by analysis 275.

Typical wells and springs in Union County

No. on pl. 2	Location	Owner or name	Topographic situation	Altitude (feet) ^a	Type of supply ^b	Depth (feet)	Diameter (inches)	Principal water-bearing bed		Length of casing (feet)	Depth to water level (feet)	Method of lift ^d	Yield (gallons a minute)	Use of water ^e	Remarks
								Character of material ^c	Geologic horizon						
259	Hartley Township 0.5 mile northeast of Laurelton State Village	Laurelton State Village	Hillside	.....	Dr	606	10	Red shale.....	Clinton.....	42	8±	T	42	P	Auxiliary supply. Reported moderate draw-down at 42 gallons a minute; large draw-down at 60 to 80 gallons a minute. Soil and boulders, 40 feet; yellow shale, 30 feet; gray shale (water-bearing), 377 feet; red shale (water-bearing), 159 feet.
260	0.7 mile north of Laurelton	Cary Lincoln.....	Canyon	.....	Dr	102	6	Green shale....	Wills Creek....	35	?	H	3±	D	
261	0.4 mile west of Laurelton	Lee Cerman.....	Hillside	.....	Dr	78	6	Red shale.....	Clinton.....	4	28±	H	3±	D	
262	1.3 miles west of Gleniron	R. J. Boob.....	do.	.....	Dr	59	6	do.	do.	21	21±	H	5.5	D	
263	0.1 mile west of Gleniron	Charles W. Blackford	Slope	.....	DD	50	6	Shale.....	Wills Creek....	10	?	H	3±	D,S	
264	0.3 mile south of Gleniron	Lewisburg Club....	Valley	.....	Dr	80	6	Red shale....	Clinton.....	29	?	H	3±	D	
265	0.5 mile east of Gleniron	B. Apple.....	do.	.....	Dr	45	6	Limestone?..	do.	20	8±	H	3±	D	
266	Hartleton.....	B. O. Cathern.....	Slope	.....	Dr	43	6	Calcareous sh.	Wills Creek....	29	?	H	3±	D	
267	Lewis Township 1.5 miles west of Sand Spring Camp	Tea Spring.....	Hillside	1,450	Sp	.....	.....	Concealed....	Juniata or Oswego	.....	.....	F	4±	N	Roadside spring formerly used for drinking, but condemned because of contamination. Temperature 55°F.
268	Sand Spring Camp..	Sand Spring.....	Canyon	1,310	Sp	.....	.....	Sandstone....	Tuscarora....	.....	.....	F	60±	D	Yield estimated. Water very clear. Temperature 50°F.
269	0.3 mile west of Swengel	Mr. Smith.....	Slope	.....	Dr	46	6	Shale.....	Wills Creek....	30	13±	H	5±	D	
270	0.8 mile west of White Springs	John Pontius.....	do.	.....	Dr	106	6	Calcareous shale	do.	57	61±	P	6+	D,S	Reported small draw-down at 15 gallons a minute.
271	Limestone Township 0.5 mile north of White Springs	Chambers estate....	Valley	.....	Sp	.....	.....	Limestone....	do.	.....	.....	F	250±	D,S	Yield estimated. Temperature 53°F.

	New Berlin.....	Rosedale Dairy.....	Slope	530	Dr	180	6	do.	Tonoloway or Wills Creek	42	+ to 18	2S	100	C.I	Reported draw-down 22 feet on pumping 100 gallons a minute continuously. Reported to flow a small amount in winter. Tempera- ture 53° F. See analysis. Another drilled well furnishes 15 gallons a minute for making ice. Reported draw-down 20 feet on pumping 12 gallons a minute.
272	do.	B. Eaton.....	do.	530	Dr	48	6	do.	Helderberg or Tonoloway	41	18±	S	12	N	
273	0.4 mile east of New Berlin	David Leiby.....	Knoll	540	Dr	33	6	Hard flinty sandstone	Oriskany....	21	14±	H	2±	S	
274	0.6 mile north of New Berlin	New Berlin Borough Waterworks	Hillside	650- 750	7 Sp			Shale.....	Clinton.....			F	(?)	P	See analysis of composite sample collected from reservoir.
275	0.3 mile south of Mifflinburg	Jerry Hartline.....	Ridge		Dr	112	6	Shaly lime- stone	Helderberg....	42	98±	H	5+	D	
276	0.2 mile west of Mifflinburg	George Chambers....	Hillside		Sp			Limestone....	Tonoloway?			F	1,500±	P.I	Yield estimated. Temperature 52° F. Water clear. Supplies 8 homes and 1 dairy.
277	West Buffalo Twp. Mifflinburg.....	Thompson & Bogen- rief, Thompson	Valley		Sp			do.	Wills Creek....			F	200±	N	Yield estimated. Reported to be on old Indian trail.
278	Forest Hill.....	James W. Eikay.....	Ridge		Dr	90	6	Shale.....	Bloomsburg	(?)	70±	H	?	D	Unimproved roadside spring. Water issues from 4 or 5 openings. Yield estimated. Temperature 50° F.
279	1.1 miles southwest of Keystone Camp	Mekean Spring.....	Hillside	1,180	Sp			Sandstone....	Tuscarora....			F	40±	D	
280	Gregg Township Alvira.....	Mr. Houtz.....	Ridge	630	Dr	64	6	Limestone....	Helderberg....	45	34±	H	10	D,S	
281	0.2 mile west of Devitt Camp	Devitt Camp.....		580	Dr	262	8	Red shale or sandstone	Clinton.....	40	18±	P	13	D,S	
282	do.	do.	do.	700	Dr	205	8	Hard brown sandstone	do.	20	+	P	13	P	Flows 1 or 2 gallons a minute. Temperature 50° F. See analysis. 200 feet from well 253.
283	do.	Walter Meek.....	do.	700	Dr	254	8	do.	do.	20	19±	P	13	P	
284	Allenwood.....	Frank Allen.....	Valley	500	Dr	84	6	Limestone....	Wills Creek....	44	?	H	5±	P	
285	do.	D. S. Botts & C. A. Grove	do.	500	Dr	101	6	do.	do.	(?)	40±	P	5	D,S	
286	0.6 mile southeast of Allenwood		do.	480	Dr	158	6	Hard brown sandstone	Clinton.....	19	19±	H	3-5	D	
287	White Deer Township 0.1 mile east of White Deer	D. R. Harbison.....	do.	470	DD	36	6	Yellow cal- careous sh.	Wills Creek....	33	?	H	5±	D,S	Reported tested at 10 gallons a minute.
288	0.3 mile south of New Columbia	Frank Showers.....	do.	460	DD	68	6	Dark sand- stone	Clinton.....	33	22±	H	5±	D	Reported draw-down 16 feet on pumping 15 gallons a minute for 1 hour.
289	0.2 mile west of West Milton	Robert Newman.....	Slope	520	Dr	98	6	Limestone and green shale	Wills Creek....	(?)	?	H	3-5	D	
290	West Milton.....	C. A. Grove.....	do.	500	Dr	45	6	Soft limestone	do.	(?)	20±	N	3-5	N	Some gravel cased off. Uses public supply.
291	Kelly Township West Milton.....	N. Showers.....	Valley	480	Dr	48	6	do.	do.	(?)	20±	H	3-5	D	Small yield, but water reported to be of very good quality.
292	1.4 miles southwest of West Milton	Mrs. Alice Darrawsky	Hillside	560	DD	99	6	Red shale....	Bloomsburg....	27	?	H	1-2	D,S	

Typical wells and springs in Union County—Continued

No. on pl. 2	Location	Owner or name	Topographic situation	Altitude (feet) ^a	Type of supply ^b	Depth (feet)	Diameter (inches)	Principal water-bearing bed		Length of casing (feet)	Depth to water level (feet)	Method of lift ^d	Yield (gallons a minute)	Use of water ^e	Remarks
								Character of material ^c	Geologic horizon						
294	1 mile south of Central Oak Heights	Charles Stein.....	Valley	470	Dr	100	8	Limestone....	Helderberg or Tonoloway	23	19±	H	1-2	D,S	
295	1.2 miles north of Lewisburg	Clarence Yoder.....	Slope	500	DD	63	6	Black shale....	Marcellus.....	41	?	H	1-2	D	
296	2 miles northwest of Lewisburg	Federal Penitentiary	Saddle	570	Dr	206	8	Limestone	Helderberg or Tonoloway	30	64	N	40	N	Used only during construction of prison. Reported moderate draw- down at 55 gallons a minute continuously.
297	do.	do.	do.	580	Dr	484	8	do.	do.	30	113+	N	50	N	Used only during construction of prison. Reported moderate draw- down at 30 gallons a minute con- tinuously. Water very hard and reported to contain hydrogen sulphide.
298	2.6 miles northeast of Mazeppa	Cyrus Hoffa.....	Slope	520	DD	60±	6	Soft limestone	Wills Creek...	33	?	P	10	D,S	
299	1.1 miles northeast of Mazeppa	Foster Emory.....	Saddle	570±	Dr	120	6	Limestone....	do.	(?)	?	P	6-7	D,S	Calcareous shale overlies limestone.
300	Buffalo Township														
300	1.2 miles northeast of Cowan	J. T. Spiegelmeyer...	Hill	.....	DD	81	6	Shaly lime- stone	do.	(?)	?	H	3±	D,S	
301	1.1 miles southwest of Mazeppa	Edward M. Reed....	do.	580	DD	67	6	Red shale....	Bloomsburg...	22±	22±	H	3±	D	
302	0.1 mile southeast of Cowan	Thomas Feters (former owner)	Hillside	.....	Dr	45	6	Yellow shale..	Wills Creek...	36	14±	H	6	D	
303	0.9 miles east of Mifflinburg	Harvey Brungard...	Valley	.....	DD	61	6	Calcareous shale	do.	40	11±	H,P	10	D	
304	0.4 mile north of Vicksburg	Ardella Leimbach....	do.	520	Dr	60	6	Limestone....	do.	15	?	H	5±	D,S	
305	0.5 mile west of Vicksburg	John C. Cline.....	do.	530	DD	40±	6	do.	do.	22	?	P	5±	D,S	
306	1 mile south of Vicksburg	Merl Kreitzer.....	Slope	610	DD	103	6	Calcareous shale	do.	63	58±	H,P	10	D,S	
307	1.1 miles southeast of Vicksburg	Mrs. McCall.....	do.	580	Dr	31	6	Limestone....	do.	24	?	H	3±	D,S	

308	1.2 miles southeast of Vicksburg	Israel Rhul.....	Valley	570	Dr	36	6	do	do	do	25	15±	H	3±	D,S	
309	1.3 miles east of Vicksburg	Mr. Gutelius.....	Low ridge	570	DD	73	6	do	do	do	(?)	?	P	10	D,S	
310	East Buffalo Township	Sheffield Farms, Inc.	Valley	470	Dr	250	6	do	do	Helderberg or Tonoloway	114	40±	P	?	N	Reported to pump dry in 15 minutes at about 100 gallons a minute. Oriskany cased off to keep out sand.
311	do	do	do.	470	Dr	104	6	do.	do.	Helderberg....	(?)	25±	P	60	C	Reported draw-down about 1 foot on pumping 60 gallons a minute for 24 hours. Temperature 53° F. See analysis.
312	do.	do.	do.	470	Dr	94	6	do.	do.	do.	(?)	40±	P	60	C	Reported draw-down about 2 feet at 60 gallons a minute.
313	do.	Plastic Products Co.	do.	460	Dr	302	8	do.	do.	Tonoloway....	50±	15±	T	45	C,I	Oriskany (30± feet) cased off. Water reported to contain hydrogen sulphide.
314	Bucknell.....	L. P. Ilgin.....	do.	480	Dr	150	8	do.	do.	Wills Creek....	8.6	30±	P	27	C	145 feet to water-bearing bed. Reported draw-down 12 to 15 feet at 27 gallons a minute. Temperature 55° F. See analysis.
315	do.	Mrs. Ella McCall....	do.	480	Dr	21	6	do.	do.	do.	15	8±	H	3±	D	
316	1.6 miles southeast of Buffalo Crossroads	Harry Walter.....	do.	560	DD	80	6	do.	do.	do.	44	44±	H	3-5	D,S	
317	1.3 miles southeast of Buffalo Crossroads	Ralph Musser.....	do.	520	DD	54	6	do.	do.	do.	(?)	40±	P	5±	D,S	
318	1 mile south of Lewisburg	(?)	Low ridge	560	Dr	150	6	Red shale....	Bloomsburg	do.	38	50±	P	7	D	Formerly owned by National Air Transport Co. and used to supply radio station.
319	0.2 mile north of Turtleville	Haowk & Lehr.....	Valley	440	Dr	49	6	Gray sandstone	Clinton.....	do.	27	16±	H	4±	D	27 feet of sand and gravel cased.
320	0.1 mile east of Turtleville	G. H. Wendt.....	do.	440	Dr	43	6	Hard sandstone	do.	do.	28.5	20±	H	5±	D	Reported draw-down 3 feet on pumping 20 gallons a minute for 1 1/2 hour.
321	Union Township	Reading Railroad Co.	do.	450	Dr	113		Hard red ss....	do.	do.	22	36±	H	6±	D	Reported draw-down 10 feet at 15 gallons a minute. Several mud seams cased.
322	0.2 mile south of Winfield	Jesse Crabb.....	Slope	460	Dr	72		Shaly limestone	Tonoloway or Wills Creek	do.	66	22±	P	5±	D	41.5 feet of water-bearing sand and gravel cased. Reported draw-down 18 feet at 12 gallons a minute.
323	0.3 mile southeast of Winfield	M. G. Dyer.....	Valley	440	Dr	47		Yellow shale...	Wills Creek....	do.	41.5	9±	H	5±	D	
324	0.5 mile south of Winfield	Joseph Roush.....	Hillside	560	DD	67		Limestone....	Helderberg....	do.	18	?	H	3-5	D,S	

^c Sh, shale; ss, sandstone.

• Altitudes taken from nearest contour or topographic maps. No topographic maps for western part of county.

Dr, drilled well; Du, dug well; DD, dug and drilled well; Sp, spring

^d F, natural flow; H, lift pump, hand-operated; N, none; P, force pump, power-operated; S, suction pump, power-operated; T, turbine pump.

^e C, condensing or cooling; D, domestic; I, industrial; N, none; P, public supply; S, stock.

Analyses of ground and surface waters from Union County

[Parts per million. 272, 275, 283, 311 analyzed by E. W. Lohr; 314, A, B analyzed by Margaret D. Foster.
Numbers at heads of columns refer to corresponding numbers in the preceding table and on pl. 2.]

	272	275	283	311	314	A	B
Silica (SiO ₂).....	.....	.....	5.9	.....	.....	.....	.....
Iron (Fe).....	.....	.....	.01	.....	.....	.....	.....
Calcium (Ca).....	56	.....	2.4	76	91	4.8	28
Magnesium (Mg).....	19	.....	2.5	14	42	1.7	9.0
Sodium (Na).....	a 6	{.....}	.9	a 4	a 1	a 1	a 1
Potassium (K).....	.....	{.....}	.6	.....	.....	.....	.....
Bicarbonate (HCO ₃).....	164	14	16	201	296	15	109
Sulphate (SO ₄).....	62	2	3.9	67	144	6.3	15
Chloride (Cl).....	21	.9	.6	9.0	6.0	1.0	2.0
Nitrate (NO ₃).....	1.8	.24	.05	9.8	.83	.25	1.0
Total dissolved solids.....	247	.....	22	279	430	22	110
Total hardness as CaCO ₃	218	14	16	247	400	19	107
Date of collection.....	Aug. 6, 1934	Aug. 6, 1934	Aug. 21, 1934	Aug. 4, 1934	Oct. 16, 1936	Oct. 16, 1936	Oct. 16, 1936

^a Calculated.

A. Sample of water furnished by White Deer Mountain Water Co., collected from tap at Northeastern Federal Penitentiary, near Lewisburg. Source of water, Spruce Run and White Deer Creek.

B. Sample of water collected from Buffalo Creek at covered bridge 2½ miles northwest of Lewisburg.

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